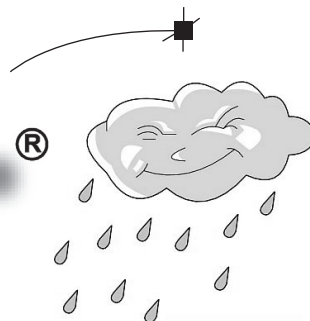


The AMSAT[®] Journal

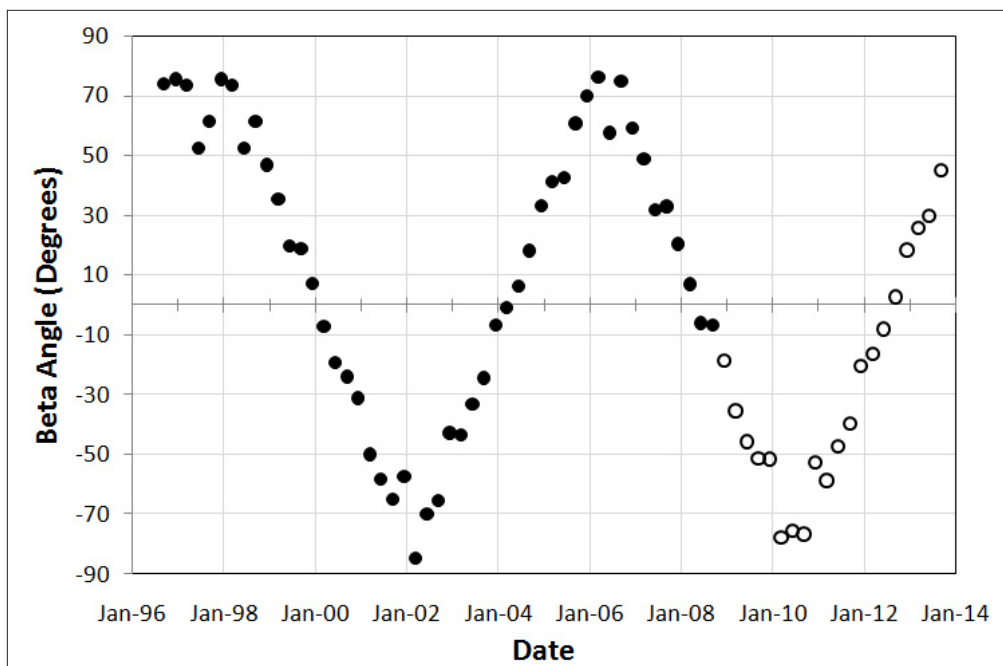


Editor-in-Chief:
Ed Long, WA4SWJ

Assistant Editors:
Bill Hook, W3QBC
Tim Lilley, N3TL
JoAnne Maenpaa, K9JKM

Volume 32, Number 2

March/April 2009



Satellite Temperature Fluctuations



AMSAT's History

in this issue

AMSAT Announcements2

Apogee View3

by Barry Baines • WD4ASW

FO-29's Frequency Variability4

and Spacecraft Temperature

by James DeYoung • N8OQ

Old Mum Can Still Talk RTTY9

by Nader Abd Elhamed Ali Omer • ST2NH

Receiving and Displaying the10

AO-51 Telemetry Downlink: A Sound Card DSP Software Modem and a Matching Telemetry Display Program

by Douglas D. Quagliana • KA2UPW

What's Inside an Antenna16

Rotator?

by Peter Carr • WW3O

First CW and FM Signals18

Produced for SuitSat-2

by Gould Smith • WA4SXM

Press Release from AMSAT-DL...21

First German Mars Mission Makes a Sidestep to Venus

Two Generations of Hams23

in Space

by Owen K. Garriott • W5LFL and Richard Garriott • W5KWQ

AMSAT is 40!26

by Ed Long • WA4SWJ

AMSAT - The First Decade28

by Bill Tynan • W3XO

Periodicals
POSTAGE PAID
At Silver Spring, MD
and at additional
mailing offices

AMSAT-NA
850 Silgo Avenue, Suite 600
Silver Spring, MD 20910-4730

How You Can Help Build New and Exciting Satellites

Donate to the President's Club

Gold, Silver, Bronze and Core levels are available to match your ability to participate.

Cash Gifts

Visa, or MasterCard or checks are accepted. And, you can specify how your contribution is to be used.

Gift of Life Insurance

US taxpayers may be able to receive a significant income tax deduction by making The Radio Amateur Satellite Corporation the owner and beneficiary of life insurance policies.

Gift of Stocks or other Securities

US taxpayers should be able to avoid capital gains taxes on appreciated securities and receive a deduction for their fair market value.

Bequest

A codicil in your will, naming The Radio Amateur Satellite Corporation as a beneficiary will help insure the continuance of the Amateur Radio Satellite program.

Call the AMSAT-NA office at 301-589-6062 for questions on any or all of these ways you can help build new and exciting satellites.

Support AMSAT-NA

AMSAT Announcements

BoD Nominations

It is time for nominations for the upcoming open seats on the AMSAT-NA Board of Directors. A nomination requires either one AMSAT Member Society or five current individual members to nominate an AMSAT member for the position. A director serves for a period of two years. Four directors' terms expire this year: Barry Baines, WD4ASW, Drew Glasbrenner, KO4MA, Rick Hambly, W2GPS and Gunther Meisse, W8GSM. Nominations must be in writing and mailed to:

**AMSAT
850 Sligo Ave #600
Silver Spring MD 20910**

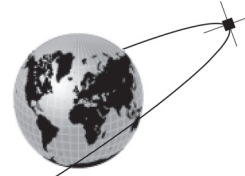
Nominations are due no later than June 12, 2009.

AMSAT's Mission

AMSAT is a non-profit volunteer organization which designs, builds and operates experimental satellites and promotes space education. We work in partnership with government, industry, educational institutions and fellow Amateur Radio societies. We encourage technical and scientific innovation, and promote the training and development of skilled satellite and ground system designers and operators.

AMSAT's Vision

Our Vision is to deploy satellite systems with the goal of providing wide-area and continuous coverage. AMSAT will continue active participation in human space missions and support a stream of LEO satellites developed in cooperation with the educational community and other amateur satellite groups.



Radio Amateur Satellite Corporation (AMSAT-NA)
850 Sligo Ave., Silver Spring, MD 20910-4703
Telephone: 301-589-6062 – Toll Free: 888-322-6728
Facsimile: 301-608-3410
AMSAT-NA Club Callsign: W3ZM
AMSAT-NA Web site: <http://www.amsat.org>

The AMSAT Journal Staff

Editor-in-Chief: Ed Long, WA4SWJ, wa4swj@amsat.org
Assistant Editor: Bill Hook, W3QBC, w3qbc@amsat.org
Assistant Editor: Tim Lilley, N3TL, n3tl@amsat.org
Assistant Editor: JoAnne Maenpaa, K9JKM, k9jkm@amsat.org
Circulation: Martha Saragovitz, martha@amsat.org

AMSAT-NA Board of Directors

Barry Baines, WD4ASW, wd4asw@amsat.org
Tom Clark, K3IO, k3io@amsat.org
Drew Glasbrenner, KO4MA, ko4ma@amsat.org
Rick Hambly, W2GPS, w2gps@amsat.org
Lou McFadin, W5DID, w5did@amsat.org
Gunther Meisse, W8GSM, w8gsm@amsat.org
Gould Smith, WA4SXM, wa4sxm@amsat.org
Bill Ress, N6GHZ, n6ghz@amsat.org - Alternate

AMSAT-NA Senior Officers

President: Barry Baines, WD4ASW
Executive Vice-President: Open
Treasurer: Gunther Meisse, W8GSM
Corporate Secretary/VP Special Projects: Lee McLamb, KU4OS
Manager: Martha Saragovitz
Vice-President, Engineering: Open
Vice-President, Operations: Drew Glasbrenner, KO4MA
Vice-President User Services: Gould Smith, WA4SXM
Vice-President Human Spaceflight: Will Marchant, KC6ROL
Vice President, Marketing: Open

Honorary Positions

Immediate Past President: Rick Hambly, W2GPS
President Emeritus: Tom Clark, K3IO
Founding President: Perry Klein, W3PK

Editorial Office: Ed Long, WA4SWJ, 6685 Southeast 108th Street, Belleview, FL, 34420-3449. Please e-mail Journal submissions to: journal@amsat.org, telephone: 262-374-1349. **Advertising Office:** AMSAT-NA Headquarters, 850 Sligo Avenue, Suite 600, Silver Spring, MD 20910-4703.

The AMSAT Journal (ISSN: 1407-3076) is published bi-monthly (Jan/Feb, Mar/Apr, May/Jun, Jul/Aug, Sep/Oct, Nov/Dec) by AMSAT-NA, 850 Sligo Avenue, Suite 600, Silver Spring, MD 20910-4703. Telephone: 301-589-6062, fax: 301-608-3410. Periodicals postage paid at Silver Spring, MD and additional mailing offices.

Postmaster: Send address changes to *The AMSAT Journal*, 850 Sligo Avenue, Suite 600, Silver Spring, MD 20910-4703.

Opinions expressed in *The AMSAT Journal* are those of the article authors and are not necessarily those of AMSAT-NA. Copyright © 2009 by AMSAT-NA, The Radio Amateur Satellite Corporation. AMSAT is a registered trademark. Reproduction of material from *The AMSAT Journal* by mechanical, electronic, photocopy or other means is prohibited unless written permission is obtained from the author.

The AMSAT Journal staff is always interested in article submissions. Whenever possible, submissions should be sent via e-mail to journal@amsat.org using plain text or word processor files; photos or figures in TIF, GIF or JPEG formats. Kindly do not embed graphics or photos in your manuscript - we prefer receiving those as separate files. AMSAT-NA reserves the right to select material for *The AMSAT Journal* based on suitability of content and space considerations. The editors of this publication are volunteers giving freely of their talents, time and efforts to produce *The AMSAT Journal*.

As I write this column, it finally looks as if Spring is approaching New England. We're enjoying temperatures in the 40's and most of the snow is gone in Eastern Massachusetts. With Spring comes the Dayton Hamvention, a 'Rite of Spring' that I always look forward to each year.

Gould Smith, WA4SXM, is doing a masterful job of organizing AMSAT's activities at Hamvention. I encourage all AMSAT members attending Hamvention to take full advantage of the AMSAT activities this year. Check the Dayton Hamvention page on the AMSAT Web site for details: <http://www.amsat.org/amsat-new/hamvention/2009/Dayton.php>.

We are truly honored to have Richard Garriott, W5KWQ, join us at Hamvention as a guest of AMSAT and ARRL. Richard made a trip to the International Space Station in October 2008 and extensively operated the Amateur Radio station on ISS. Richard is the son of Owen Garriott, W5LFL, who made the first Amateur Radio contacts from the Space Shuttle in 1983. Richard's trip commemorated the 25th anniversary of Owen's historic flight.

Richard, W5KWQ, is the keynote speaker at the joint AMSAT-TAPR dinner on Friday evening and will also make a short presentation during the AMSAT Forum on Saturday (1115-1330 in Forum Room 4). We also expect Richard to visit the AMSAT booth as well. Tickets to attend the Joint AMSAT-TAPR dinner are available from the AMSAT Store. Reservations must be made prior by Monday, 11 May for the dinner. We look forward to seeing you at the dinner and the AMSAT booth.

Along with the social events we expect to have a very busy AMSAT booth, including an engineering area that will highlight the equipment being developed for SuitSat-2. This is a great opportunity for members to see the great work being done to develop a new generation of SDX (Software Defined Transponder) module, transmitter and receiver modules, and associated support modules, such as the Internal Housekeeping Unit. Our expectation is that the development work being done for SuitSat-2 will lead to new technology applicable for other satellite projects.

Along with highlighting SuitSat-2 development, we'll also be giving recognition to AMSAT's 40th Anniversary year. We expect

to have some 'artifacts' on hand to help celebrate a special year for AMSAT. Gould continues to look for volunteers to man the AMSAT booth during this three-day event. Please contact Gould (wa4sxm@amsat.org) if you're willing to spend a couple of hours helping out at the AMSAT booth (#444-449, located in the Ballarena).

AMSAT Lab

A significant achievement took place on Monday, 16 March when a team of AMSAT volunteers led by Bob Davis, KF4KSS, removed the AMSAT equipment from what was at one time the AMSAT Integration Lab at the Hawk Institute for Space Sciences (HISS) in Pocomoke City, MD. We reached agreement with HISS to allow our volunteers to remove all of our equipment (not including the clean room). On short notice, a team descended on the facility early on Monday. Within 15 hours, all equipment was removed from the facility with most of the material trucked to a facility about 90 minutes north of Pocomoke. Our equipment is now at a facility provided by Bill Windsor, KB3HSJ, of Hurlock, MD who owns a tower construction company. Bill supplied two trucks with trailers to haul our equipment to his storage facility, making two round trips in one day. He also provided four employees to supplement the corps of AMSAT volunteers: Bob Davis, KF4KSS; Ray Fantini, KA3EKH; Rick Hambly, W2GPS; Rob Renoud, K3RWR, and JC Taylor, W3JCT. Many thanks to the entire team for pulling off a significant achievement in getting several tons of material removed and relocated in only one day.

Unfortunately, litigation continues regarding the status of the clean room itself. We remain hopeful that an agreement will be reached regarding our intention to remove the clean room and to seek compensation for costs associated with the installation and subsequent disassembly and eventual relocation of the clean room to a new lab facility.

Discussions continue regarding finding an eventual home for the AMSAT Lab. While it is too early to project when an agreement

continued on page 26 ...



FO29's Frequency Variability and Spacecraft Temperature

by James A. DeYoung, N8OQ (ex KG4QWC), n8oq@arri.net

On 20 April 2007, FO-29 (other names are JAS-2, 24278 and 1996-046B) was found off the air by SV1BSX on a pass over Europe [1]. I captured telemetry on 19 April 2007 and noted nothing unusual in the values [2]. I also noted after review of historical AMSAT-BB submissions that FO-29 had previously been silent beginning on 8 April 2004 as first noted and reported by N7EQF [3]. The apparent root cause of FO-29 being off the air in both cases was reduced battery capacity and long eclipse durations, which prevented full battery charging during sunlight. This resulted in the inability of the power system to provide full holdover power during the eclipse periods. I began measuring the FO-29 V/U loopback frequency offsets during July 2006. Later, in January 2007, I started monitoring the beacon frequency. Slowly changing frequency variations were observed in both. The temperature variation appeared to be related to eclipse duration similar to what was observed and reported for AO-7. Basic information on details of the hardware setups and the measurements made were published in the previous paper concerning AO-7 [4]. A theory was posited that satellite temperature variation was affecting the FO-29 local-oscillator (LO) frequency stability and offered the possibility of relating ground-station measured frequencies to the spacecraft average temperature.

This paper will show the results of associating the N8OQ ground station measured relative transmit to receive (V/U) transponder loopback frequency variation with average spacecraft model temperature. In addition, the absolute 70 cm beacon frequency variation to average satellite model temperature will be developed. Estimates will be formed of the average emissivity and absorptivity of the spacecraft. Simply by measuring relative loopback frequency changes or the absolute beacon frequency variation one has a link to the spacecraft temperature. These relationships will be usable to get spacecraft temperatures even when the telemetry beacon values are "bad" or if the beacon/telemetry system is off the air.

The observed variation of the FO-29 loopback and beacon frequencies

Originally, I began monitoring the FO-29 loopback frequency offsets of both the V/U transponder and the U-band beacon

to characterize their behavior since I didn't know if they would be stable or not. As the measurements were made they were entered and plotted both as a simple time-series and against the daily average percentage of time in eclipse in a spreadsheet. Satellite Contact Report Analysis and Prediction (SCRAP) [5] was used to generate the daily average percentage of eclipse. The percent eclipse time has a direct physical relationship to spacecraft temperature and FO-29 does not disappoint by showing a strong relationship with the percentage of eclipse. Figures 1 and 2 are plots of the frequencies measured at the N8OQ ground station plotted against solar illumination percentage. The beacon frequency range is not fully covered due to monitoring beginning at a later date than the transponder loopback monitoring.

Validation of an FO-29 Thermal Model using Telemetry

The Beta angle is a useful parameter for understanding spacecraft thermal performance for near-circular low-earth orbits. When the Beta angle is zero, the Sun-satellite vector is in the orbital plane resulting in maximum eclipse times. Alternatively, when the Beta angle is at 90-degrees, the

satellite orbital plane is normal to the Sun vector resulting in the spacecraft always being in full sunlight. Due to orbital plane precession the Beta angle of FO-29 slowly changes with time. The full precession period is about 8.5 years. A Beta angle of zero degrees repeats about every 4.25 years for FO-29 and it is around these times the maximum eclipse times are reached and any spacecraft power deficiencies would be most impacting. The next maximum eclipse period will be expected in mid-2012 when the FO-29 power budget will be stressed again. See Figure 3.

FO-29 uses passive thermal control. The solar cell (Gallium Arsenide) cover glass and applied coatings on the non-solar cell surface structures were adjusted by the builders for acceptable thermal control [6]. In addition, FO-29's attitude is maintained in spinning "wheel mode" which means the satellite spin axis is normal to the plane of the orbit and is designed to smooth temperature variations. To associate the observed relative loopback and absolute beacon frequency variation to spacecraft average temperatures, a model for the spacecraft temperature from the standard thermal equilibrium equations was needed.

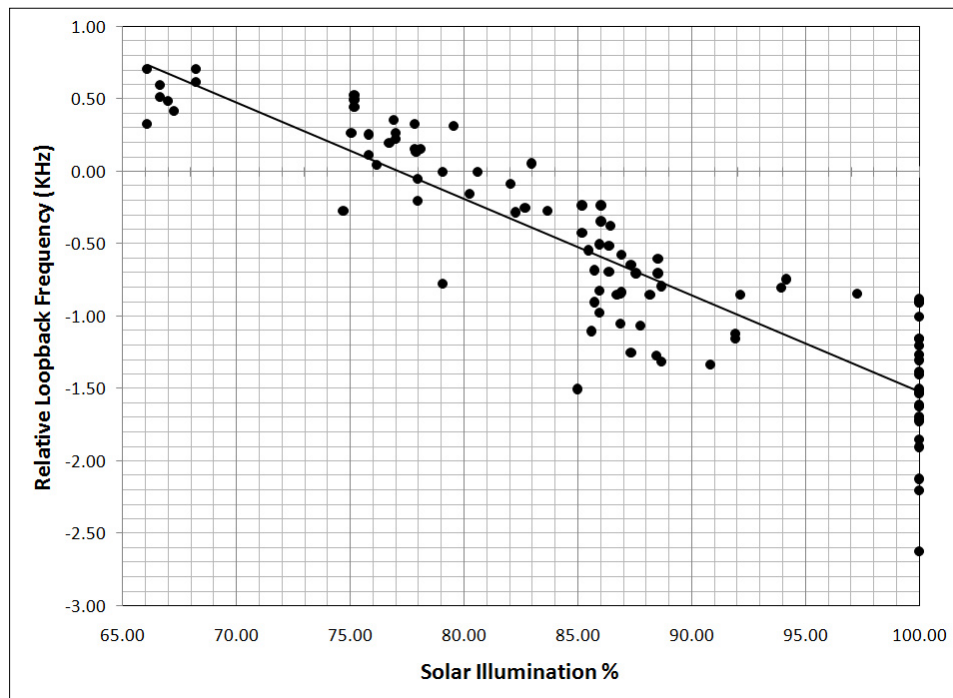


Figure 1: This is a plot of loopback frequency variation with respect to daily FO-29 percent illumination by the Sun during the day. The linear least squares fit line is $LBF = -0.0667 * SI\% + 5.1490$. LBF is the transponder loopback frequency offset while SI% is the solar illumination percentage. The correlation coefficient was 0.895 and the standard error estimate was 0.340. A leveling is apparent between about 87% to 100% illumination. A similar leveling was also seen in AO-7 [4].

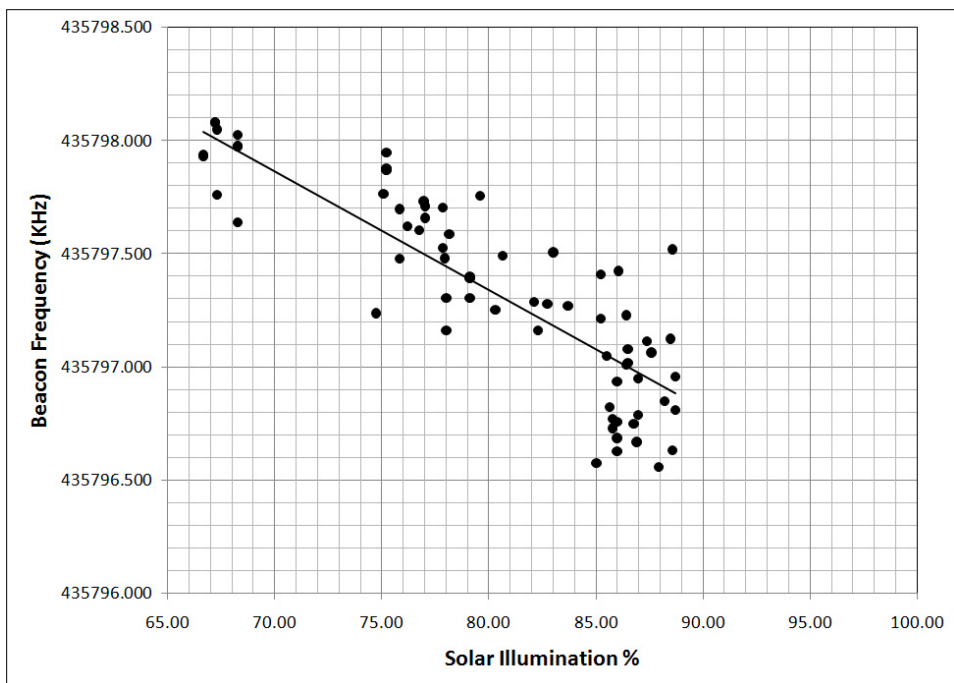


Figure 2: This is a plot of the absolute beacon frequency variation with respect to the daily FO-29 percent illumination by the sun during a day. The linear least squares fit line is $BCNf = -0.0524 * SI\% + 435801.528$. $BCNf$ is the measured beacon frequency (kHz) and $SI\%$ is the solar illumination percentage. The correlation coefficient was 0.85 while the standard error estimate was 0.229. The full range of illumination percentages is not covered because the beacon frequency measurements were started later than the loopback frequencies. Enough data is in hand to get the general trend, however.

The ARRL's *Radio Amateur's Satellite Handbook* has a chapter on satellite systems which discusses the basics of estimating orbital average satellite temperatures using energy input, output and balance equations [7]. Equation 1 gives the direct solar radiation (P_{ds}) impinging on a spacecraft

adjusted for the variation in the Earth – Sun distance between perihelion and aphelion (3.4% variation).

$$P_{ds} = P_0 \left(\frac{1}{R^2} \right) \quad 1)$$

P_0 is the direct solar radiation constant (1366-watts/m²) [8],[9] and R is the Earth to

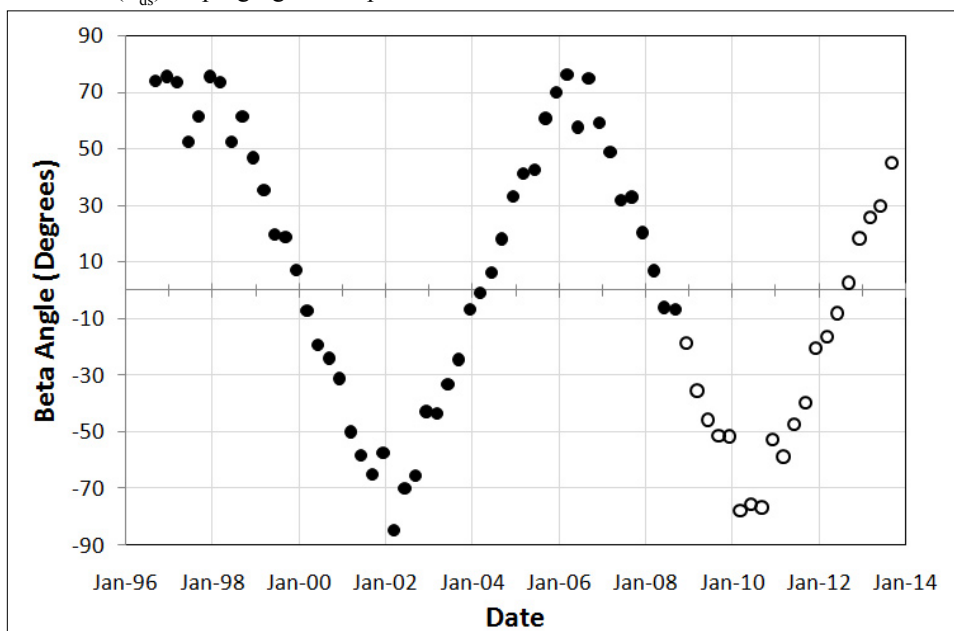


Figure 3: This plot shows the variation of the Beta angle for FO-29 from launch until October 2008 (filled circles) and then extrapolated forward using an October 2008 TLE propagated using SGP4 (open circles). Maximum eclipse times occur when the Beta angle is at zero. The maximum eclipse period repeats about every 4.25 years and inspection of the figure shows the next maximum eclipse period will occur during the summer of 2012.

Sun distance in astronomical units (AU).

For the thermal equations we need the total surface area as well as the portion of the surface illuminated directly by the Sun for FO-29. Since, this spacecraft is a relatively complex 26-sided polyhedron it was decided for simplicity to approximate its areas by using a simple spherical area approximation. A sphere diameter of 0.455-m was chosen and the total area of the sphere computed in the usual way giving 0.6504-m². The area illuminated by the direct rays of the Sun is simply 1/2 of the total area or 0.325-m².

Another component applicable to spacecraft thermal behavior is Earth albedo (A_e) heating by reflected solar and earth radiated energy. The following equation accounts for this component of heating.

$$A_e = \{[(1 - ealb) * P_{ds}]/4\} * scf \quad 2)$$

$ealb$ is the average Earth albedo (0.3) and scf is the spacecraft height and shape correction, sometimes called the shape factor or shape modulus correction (0.19) [10],[11]. FO-29 is in a fairly eccentric orbit with perigee near 806-km and apogee near 1338 km, mean 1072 km. The total Earth albedo contributed heating variation at the average altitude of FO-29 (1072 km) is about 2.8% of the direct solar heating. Bringing all factors together into the standard spacecraft thermal equation gives

$$T = \sqrt[4]{\frac{(P_{ds} + A_e) A \alpha \beta}{\langle A \rangle \sigma e}} \quad 3)$$

T is the model average spacecraft temperature, A is the illuminated surface area of FO-29 (0.325 m²) by direct solar rays, α is the satellite average surface absorptivity, β is the fraction of orbit in sunlight, $\langle A \rangle$ is the effective capture area, i.e. the total surface area of FO-29 (0.6504-m²), σ is the Stefan-Boltzmann constant (5.67x10⁻⁸ joules/Kelvin⁴m²s), and e is the average surface emissivity.

Since no specific values for absorptivity or emissivity were found in the literature, estimates for the two values were needed. Initial values for absorptivity and emissivity, based on the apparent materials used in the construction of FO-29, were formed. The outer surface of FO-29 is dominated by solar cells (about 75% of the total area) while the rest was originally bright shiny metal (about 25% of the total area). The initial spacecraft average absorptivity was estimated to be around 0.85 and the emissivity was set at 0.48.

With the absorptivity fixed at 0.85 the



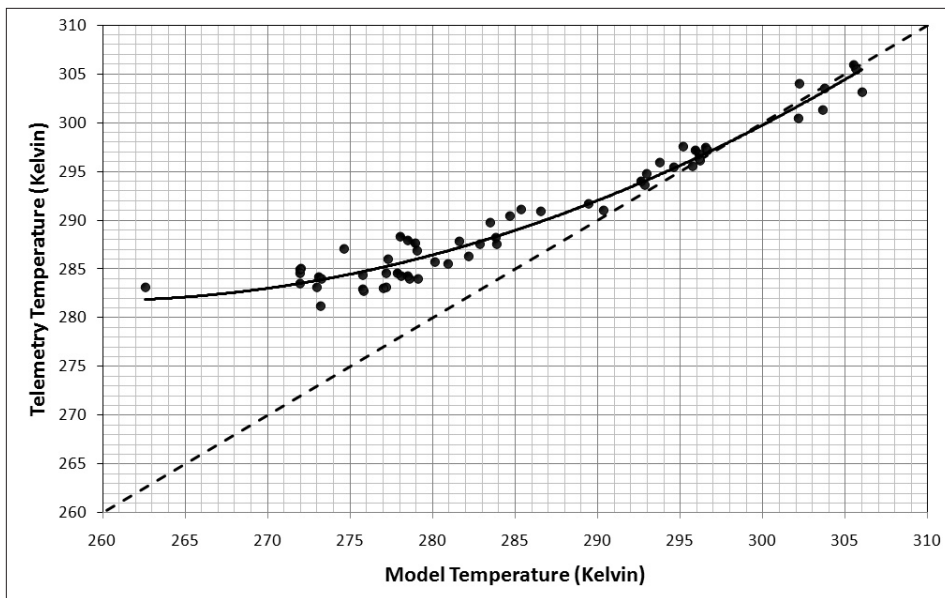


Figure 4: This is a plot of the telemetry reported temperatures plotted against the standard thermal model. The FO-29 average temperature was formed from the simple average of all four structure temperatures. A second order disagreement is evident. The dashed line is the expected optimal one-for-one slope relationship.

emissivity was then adjusted by solving equation 3 and comparing to the average structure temperature formed from the four structure temperatures reported in telemetry. The final best guess of emissivity was 0.58 when matching to the full sunlight period, i.e., the highest spacecraft equilibrium temperatures. Both raw and already reduced telemetry was obtained from the Web mostly from that submitted to the AMSAT-BB. The author also collected some of the telemetry used here. Any raw CW/Morse code telemetry was decoded using JE9PEL's program fo29cwte [12].

Equation 3 accounts for nearly all of the frequency variation, however a second

order variation remains, (Figure 4). A purely empirical (non-physical) second order polynomial least squares fit was made to have the thermal model fit the reported telemetry in a linear fashion (Figure 5).

$$T_c = T + C$$

T_c is the corrected model spacecraft temperature, T is from equation 3 and C is the correction to be added given by:

$$C = 0.0108 * T^2 - 5.609 * T + 1008.6956 \quad 4)$$

The fit correlation coefficient was 0.979 and the standard error estimate was 1.412.

Evaluating equation 3 and correcting using

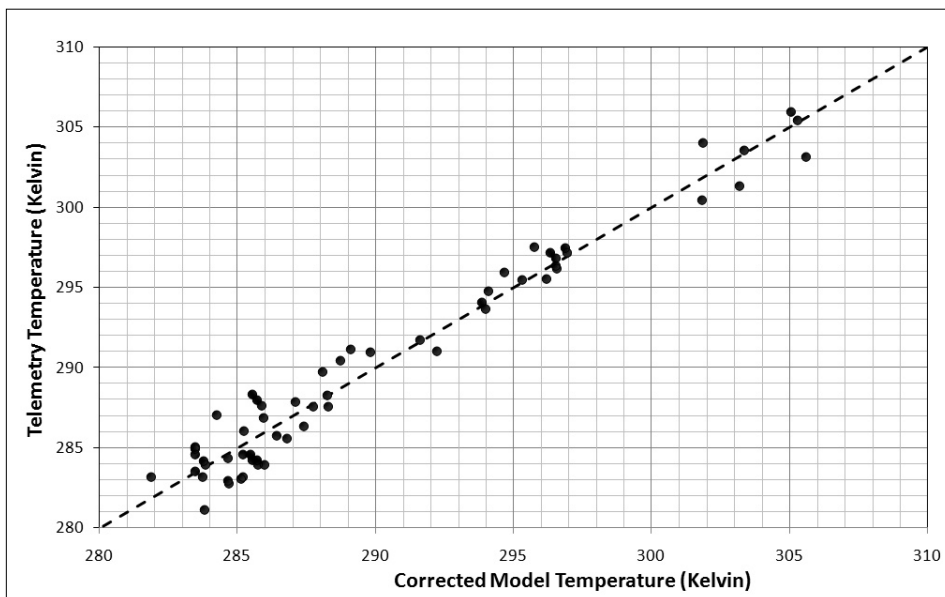


Figure 5: This is a plot of the corrected thermal model after empirical linearization.

equation 4 over the sunlight to eclipse ratio range of 0.65 to 1.0 per orbit gives corrected model temperatures that seem reasonable. The average spacecraft temperature of 293°K is nice shirt-sleeve weather (68°F). In full sunlight, the spacecraft is a bit more balmy at 303°K (86°F). The coldest average spacecraft temperatures are a cool 283.6°K (50°F). Table 1 gives corrected model temperatures using equations 3 and 4 (R fixed at 1 AU). Evaluating equations 3 and 4 using extreme values of R (0.983 AU to 1.017 AU) gives extreme model temperatures of 283.6°K to 303.1°K. The resultant model temperatures seem to be very reasonable and no further adjustment was deemed necessary.

Relating the measured loopback frequency to the model temperature

Conveniently, equations 3 and 4 relate the solar illumination percentage directly to spacecraft temperature. This average spacecraft temperature model allows the formation of a simple relationship to the ground-based measured frequency variation. The physical basis of the observed FO-29 frequency variation is the temperature dependency of the FO-29 LO electronics which generates the transponder reference and translation frequencies and the 2m beacon frequency. The linear least-squares method was used to fit the measured relative loopback frequency (kHz) and model temperature (Kelvin).

Equation 5 allows recovery of the model temperature from the observed relative loopback frequency measurement.

$$LBT_k = \frac{(MLB_f - 30.4)}{-1.05} \quad 5)$$

LBT_k is the spacecraft average temperature based on the measured loopback frequency offset MLB_f . The correlation coefficient was 0.924 and the Standard Error Estimate was 0.291.

Figure 6 shows the final relationship of loopback frequency variation and FO-29 model temperature. It is quite good.

Relating the measured 70-cm beacon frequency to the model temperature

Figure 7 shows the relationship of the FO-29 model temperature and absolute beacon frequency. The linear least-squares method was used to fit the measured absolute beacon frequency (KHz) and model temperature (Kelvin).

Equation 6 allows recovery of the corrected model temperature from the observed

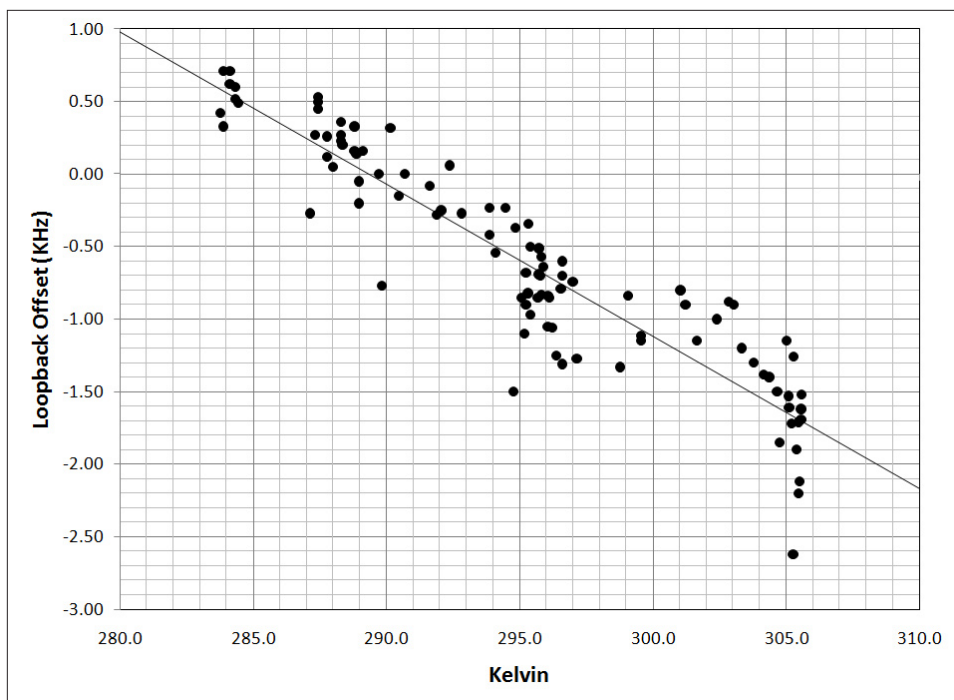


Figure 6: The FO-29 loopback frequency as measured by N8OQ plotted against corrected model temperature. A “shelf” is seen between 297 Kelvin and 303 Kelvin and is similar to what was seen in an AO-7 analysis [4].

absolute beacon frequency measurement.

$$BCNT_k = \frac{(MB_f - 435822.5)}{-0.087} \quad (6)$$

$BCNT_k$ is the spacecraft average temperature based on the beacon frequency in and MB_f is the measured beacon frequency. The correlation coefficient was 0.879 while the standard error estimate was 0.209.

Figure 7 shows the final relationship of

the beacon frequency variation and FO-29 model temperature. It is very good.

Discussion and conclusions

As was seen in AO-7 there is some left-over structure in the temperature vs frequency relationship, “the shelf” seen around the transition period between full sunlight and eclipse periods could possibly be accounted for in the future as a longer time-series is accumulated. Three possible things to

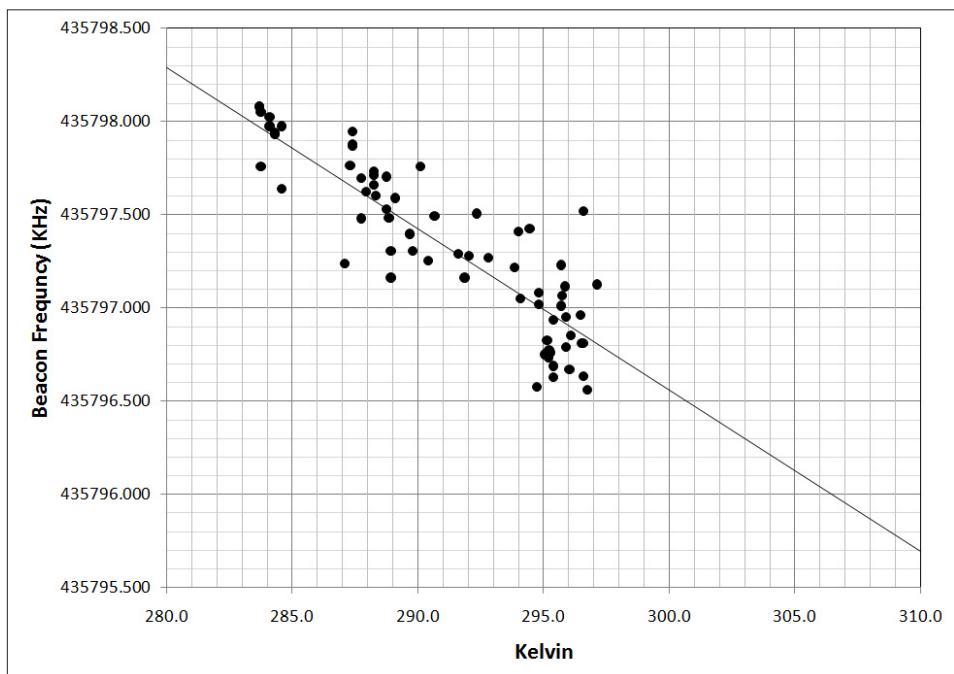


Figure 7: The FO-29 beacon absolute frequency as measured by N8OQ plotted against the corrected model temperature.

consider for improvement in the future is a more detailed model of the Earth IR contribution to FO-29's temperature, a model of possible Earth terminator effects as FO-29 transitions between eclipse and illumination. Understanding any dependence on spacecraft wheel-mode spin attitude related to Beta angle. It should be possible to add FO-29 height variation above Earth into equation 3 which currently has an average fixed height included in the scf value but it should not be a large factor.

It is very good to have FO-29 again available to amateur satellite communicators. It may last until just before the next Beta angle zero crossing around the spring or summer of 2012. Thanks to the efforts of the FO-29 command team FO-29 was recovered as the Beta angle has moved farther away from zero.

References

- [1] SV1BSX, “FO-29 Problem”, 20 Apr 2007 06:10:08, The AMSAT Bulletin Board, (AMSAT- BB), <http://www.amsat.org/amsat/archive/amsat-bb/index.html>
- [2] DeYoung, James (KG4QWC), “FO-29 Off”, 20 Apr 2007 15:31:09, The AMSAT Bulletin Board, (AMSAT- BB), <http://www.amsat.org/amsat/archive/amsat-bb/index.html>
- [3] Albert Ozias (N7EQF), “FO-29 Batteries?”, 8 Apr 2004 23:36:03, The AMSAT Bulletin Board, (AMSAT- BB), <http://www.amsat.org/amsat/archive/amsat-bb/index.html>
- [4] DeYoung, James A. (KG4QWC), “AO-7's Frequency Variability as a Proxy for Spacecraft Temperature”, AMSAT J., May/June 2007, pp. 23-26.
- [5] SCRAP, <http://www.amsat.org/amsat/catalog/software.html>
- [6] Yamashita, Fujio (JS1UKR), (1995), “JAS-2 Now Under Preparation”, AMSAT J., Vol. 18, Sept/Oct., pp.24-29.
- [7] Davidoff, M. (2000), The Radio Amateur's Satellite Handbook, 1st Revised ed., ARRL, Newington, CT, p. 14-12.
- [8] Froehlich, C., and Lean, J., (1998), “The Sun's total irradiance: Cycles and trends in the past two decades and associated climate change uncertainties”, Geophys. Res. Lett., 25, p. 4377-4380.



Table 1

Ratio/% Sunlight/Eclipse	Kelvin	Celsius	Fahrenheit	Ratio/% Sunlight/Eclipse	Kelvin	Celsius	Fahrenheit
0.65 (65%)	283.6	10.5	50.4	0.83 (83%)	291.8	18.7	65.7
0.66 (66%)	283.9	10.8	50.9	0.84 (84%)	292.4	19.3	66.7
0.67 (67%)	284.3	11.2	51.4	0.85 (85%)	293.0	19.9	67.8
0.68 (68%)	284.6	11.5	52.2	0.86 (86%)	293.6	20.5	68.9
0.69 (69%)	285.0	11.9	52.7	0.87 (87%)	294.2	21.1	70.0
0.70 (70%)	285.4	12.3	53.4	0.88 (88%)	294.8	21.7	71.1
0.71 (71%)	285.8	12.7	54.1	0.89 (89%)	295.5	22.4	72.3
0.72 (72%)	286.2	13.1	54.9	0.90 (90%)	296.1	23.0	73.4
0.73 (73%)	286.6	13.5	56.3	0.91 (91%)	296.8	23.7	74.7
0.74 (74%)	287.1	14.0	57.2	0.92 (92%)	297.5	24.4	75.9
0.75 (75%)	287.5	14.4	57.9	0.93 (93%)	298.1	25.0	77.0
0.76 (76%)	288.0	14.9	58.8	0.94 (94%)	298.8	25.7	78.3
0.77 (77%)	288.5	15.4	59.7	0.95 (95%)	299.5	26.4	79.5
0.78 (78%)	288.5	15.9	60.6	0.96 (96%)	300.2	27.1	80.8
0.79 (79%)	289.0	16.5	61.7	0.97 (97%)	300.9	27.8	82.0
0.80 (80%)	290.1	17.0	62.6	0.98 (98%)	301.7	28.6	83.5
0.81 (81%)	290.7	17.6	63.7	0.99 (99%)	302.4	29.3	84.6
0.82 (82%)	291.2	18.1	64.6	1.00 (100%)	303.1	30.0	86.0

Table 1: A table showing the daily percent of orbit in sunlight for FO-29 and the corrected model temperature developed in this paper given in units of Kelvin, Celsius and Fahrenheit.

[9] <http://www.pmodwrc.ch/pmod.php?topic=tsi/composite/SolarConstant>

[10] Cunningham, F.G., (1961), "Power Input to a Small Flat Plate from a Diffusely Radiating Sphere, with Application to Earth Satellites, NASA Technical Note D-710, p11-12.

[11] "Earth Orbit Environmental Heating", NASA GD-AP-2301, NASA Preferred Reliability Practices, pp.1-5, <http://arioch.gsfc.nasa.gov/302/pdf/2301.pdf>.

[12] JE9PEL, Mineo Wakita, fo29cwte, <http://www.ne.jp/asahi/hamradio/je9pel/fo29cwth.htm> 



Old Mum Can Still Talk RTTY

by Nader Abd Elhamed Ali Omer, ST2NH, st2nh@yahoo.com

AO-7 was designed to send either CW or RTTY telemetry data as commanded by the ground control station. After stations reported copying the long silent RTTY telemetry beacon, AO-7 Command Operator, Mike, N1JEZ, noted, "This is pretty significant. Every time I've tried to activate the RTTY system on 435.100, all I would get is a solid carrier then the bird has reset indicating a lack of power. The 70 cm RTTY beacon has been monitored with strong signals worldwide since February 28, 2009 when AO-7 is operating in Mode A.

The RTTY beacon has been non-operational since 2002. Ground stations have relied upon the CW telemetry data to monitor systems status. Additional historical information is available on-line at http://www.observations.biz/AO7_Stuff.

After David, VK5DG, reported via the amsat-bb e-mail list receiving the AO-7 RTTY TLM Beacon at his QTH in Australia, I checked my tracking program and noted that within a couple of orbits it would be a good pass at my QTH. I felt energized to give it a try and listen to the history as AO-7 spoke its new language.

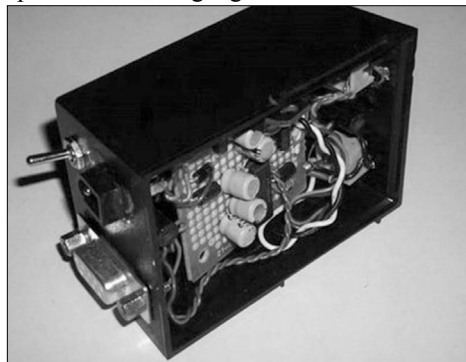


Figure 1: ST2NH homebrew sound card interface.

Here are the steps I followed leading to my successful copy of the RTTY beacon:

- I checked the AO-7 operating mode at the Live OSCAR Satellite Status Page <http://oscar.dcar.org/index.php>. Mode A means you may have a chance to copy the RTTY beacon.
- I fired up my HRD satellite tracking software that also performs Doppler correction for me. I reloaded fresh Keps data and synchronized my PC clock. I used a homebrew computer sound card interface between my PC and IC-910 radio. (See Figure 1.)

- I fired up my RTTY software MMTTY version 166G and setup the parameters as 45 baud, 85 shift. I set the software squelch slider about one third up, just to keep garbage out. See <http://mmhamsoft.amateur-radio.ca/mmtty/> to learn about this software and download your copy. (See Figure 2.)

- I connected the audio from my radio to the soundcard microphone input. My homebrew UHF antenna also includes a preamp. (See Figure 3.)

- I monitored the downlink beacon frequency of 435.100 USB (adjusting for Doppler).

At first I expected the signal to be quite weak so I opened the SQL bar on the MMTTY user interface. The elevation was -2 degrees then -1 degrees and I was feeling the adrenaline as I waited for my chance to copy history! Could I copy a language not spoken for more than 30 years? Then WOW and really a big WOW I saw immediately two lines on the waterfall. AO-7's UHF downlink signal was quite strong even as the satellite was just rising. Then the software began to copy row of digits. Yes it was AO-7 RTTY TLM.



Figure 3: ST2NH UHF antenna system.

AO-7 RTTY telemetry is organized into numbered "channels". The data format and conversion formulas have been preserved on-line in the AMSAT Newsletter PDF scans done by Phil Karn, KA9Q at: <http://www.ka9q.net/AMSAT-Newsletter-1974.pdf> (the article begins on Page 9).

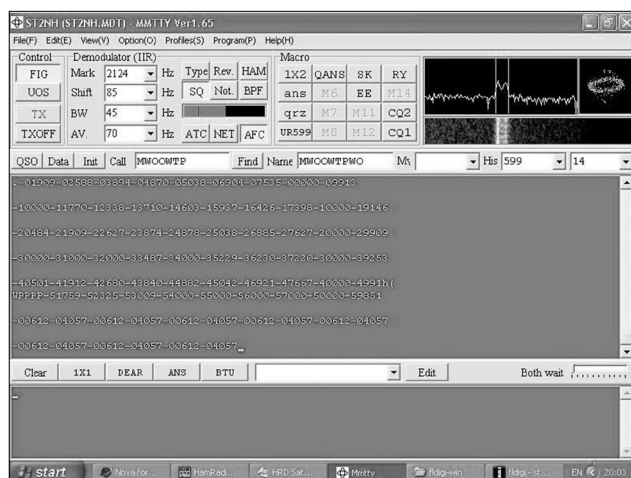


Figure 2: MMTTY screen shot showing received telemetry.

Table 1 is an example of the raw data as it arrives in your RTTY software.

Mike, DK3WN, released an AO-7 RTTY telemetry decoder beta version and is available for download at: http://www.dk3wn.info/files/ao7_rtty.zip. Tom, K3IO, provided details of setting up the decoder at his shack. Tom noted you may need to download his library of ActiveX (.ocx) files from <http://www.dk3wn.info/files/ocx.zip> and unzip it into your ..\windows\system32\ directory. Also you may need to update your Microsoft VB6 Runtime files available from Mike at <http://www.dk3wn.info/files/vbrun60sp3.EXE>.

Table 1

-00366-01899-02609-03895-04875-05054-06891-07620-00000-09913
-10000-11769-12336-13710-14603-15937-16424-17397-10000-19147
-20484-21899-22596-23903-24719-25021-26883-27600-20000-29909
-30000-31000-32000-33499-34000-35233-36229-37217-30000-39253
-40501-41912-42640-43882-44883-45060-46917-47562-40000-49921
-50000-51765-52323-53009-54000-55000-56000-57000-50000-59848
-00650-02047-00650-02047-00650-02047-00650-02047-00650-02047
-00650-02047-00650-02047-00650-02047-00650-02047-00650-02047
-00366-01915-02698-03786-04874-05038-06909-07714-00000-09913
-10000-11769-12337-13709-14603-15937-16432-17401-10000-19134
-20483-21909-22715-23764-24873-25021-26883-27727-20000-29908
-30000-31000-32000-33499-34000-35233-36231-37226-30000-39254
-40501-41914-42776-43743-44879-45016-46918-47674-40000-49918
-50000-51762-52323-53009-54000-55000-56000-57000-50000-59851
-00650-02047-00650-02047-00650-02047-00650-02047-00650-02047
-00650-02047-00650-02047-00650-02047-00650-02047-00650-02047
-00366-01916-02791-03649-04874-05017-06909-07801-00000-09912
-10000-11768-12336-13711-14603-15937-16425-17398-10000-19125
-20484-21911-22819-23655-24874-25017-26888-27824-20000-29902
-30000-31006-32000-33483-34000-35234-36239-37243-30000-39256
-40501-41915-42829-43640-44876-45017-46923-47827-40000-49918
-50000-51748-52265-53009-54000-55000-56000-57000-50000-59849
-00650-02047-00650-02047-00650-02047-00650-02047-00650-02047
-00650-02047-00650-02047-00650-02047-00650-02047-00650-02047
-00366-01913-02844-03539-04829-05017-06909-07801-00000-09912
-10000-11660-12230-13641-14603-15934-16400-17394-10000-19147
-20484-21913-22901-23576-24803-25029-26887-27883-20000-29805
-30000-31103-32000-33495-34000-35235-36249-37261-30000-39256



Receiving and Displaying the AO-51 Telemetry Downlink: A Sound Card DSP Software Modem and a Matching Telemetry Display Program

Douglas D. Quagliana, KA2UPW, dquagliana@aol.com

Abstract

The author presents a sound card DSP modem used for receiving and displaying satellite digital signals along with a matching visual telemetry program for viewing and analyzing the satellite telemetry from AO-51.

Introduction

Satellite telemetry is a collection of measurements that the spacecraft makes and then transmits to the ground. In the particular case of the satellite AO-51 (formerly "Echo"), the telemetry measurements include temperatures, voltages and currents from various subsystems and components such as the solar panels, the batteries and the radios as well as a collection of status bits and control values. The telemetry tells us all about the spacecraft and it is the only way for us to know what is happening to it: How hot (or cold) is the spacecraft? How long are the eclipses lasting this month? How much power is available to run the radios and experiments? How fast is the satellite spinning? Telemetry provides the answers.

All of the telemetry measurements are collected together into a packet and sent out via radio signals. AO-51 transmits its

telemetry on 435.150 MHz at 9600 baud as AX.25 packets that are sent using G3RUH modulation. A typical satellite ground station for receiving the telemetry uses a narrowband FM receiver. The audio from the receiver's discriminator is sent to a TNC. The TNC acts like a modem to convert the audio back into bits, reassembles the packet and checks to make sure that everything is received correctly. If it was, then the TNC reformats the packet and sends the packet over a serial cable to the computer. On the computer, a telemetry program listens to the serial port for the incoming packet and then parses out each of the measurements. For each measurement, a calculation is performed to convert the received value (for example, nineteen) back into the actual measured value on spacecraft (perhaps eight degrees Celsius). With over sixty telemetry channels measured per packet and several packets per minute, you really want a computer to do all the calculations. After all of this, we can see the measured temperatures, voltages and currents.

There are a few challenges, especially when it comes to acquiring all of the necessary pieces and getting them to work together.

The beginner is unlikely to have all the pieces already. Radio receivers are common enough, but you also need a TNC with a 9600 baud modem. Modern computers, especially laptops, are less and less likely to have a built-in serial port for talking to the TNC. In addition, the telemetry itself is less interesting if you don't know what it is, what it means, or even what the measured thing looks like. The telemetry is more interesting when you can see what it is that's being measured instead of just a bunch of columns of numbers. Lastly, once the data comes into the computer over the serial port, it typically goes to the telemetry program, and that's the only place it goes. There usually aren't any options for sharing the serial port with another program.



Figure 2: Willow LED panel.

Willow and Sabins

Willow is a digital signal processing program that either reads an audio recording or receives audio from a sound card and then demodulates 9600 and 38400 baud AX.25 packet signals, including the telemetry

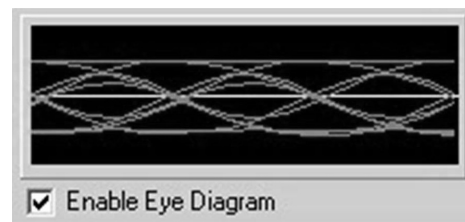


Figure 3: Willow eye diagram.

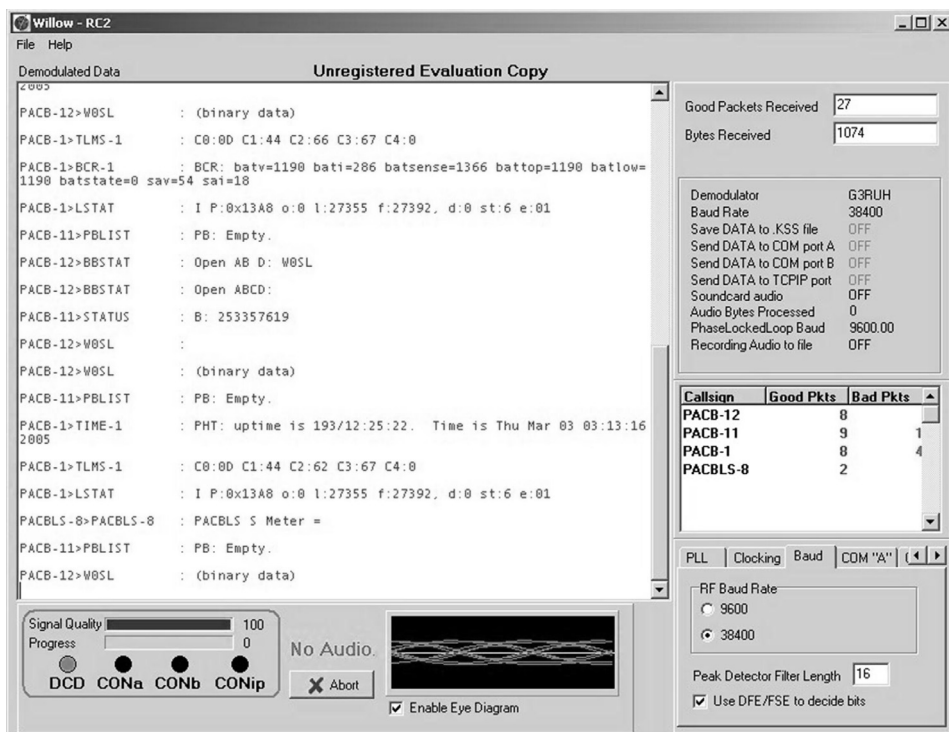


Figure 1: Willow user screen.

packets. The received packets can be displayed in any of several user-selectable formats including TNC2 style, optionally with a hexadecimal dump of the packet. Packets with a good CRC will be displayed in green, and packets with a bad CRC will be displayed in red or not at all if desired.

For demodulation, the modem incorporates a numeric oscillator, an interpolator for 38400 baud, a pair of moving-average peak detectors [1] and a fractionally spaced equalizer with decision feedback. The demodulated raw bits are NRZI decoded and unscrambled [2], framed up into AX.25

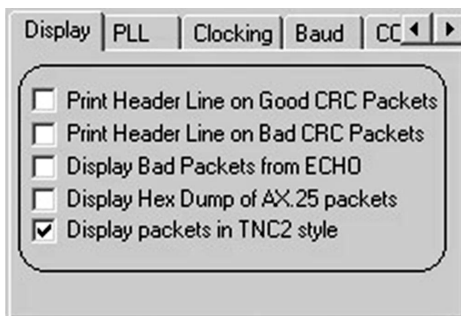


Figure 4: Willow user configurable options.

packets and checked for valid CRCs. Willow is designed to be very versatile. When a valid packet is received, it can be processed in multiple ways simultaneously: the packet can be displayed to the screen, reformatted as a KISS packet and sent out a serial port, sent out a second serial port, sent over TCP/IP and saved in KISS format to a .KSS file.

Callsign	Good Pkts	Bad Pkts
PECHO-11	503	276
PACBLS-8	17	3
PECHO-12	11	
PACB-1	138	47

Figure 5: Willow callsigns and packets received.

One interesting use of the TCP/IP connection is to send the AX.25 packets to a telemetry program running on the same PC. Originally, I wrote a simple program called Sabins [3] to display AO-51 (Echo) telemetry received

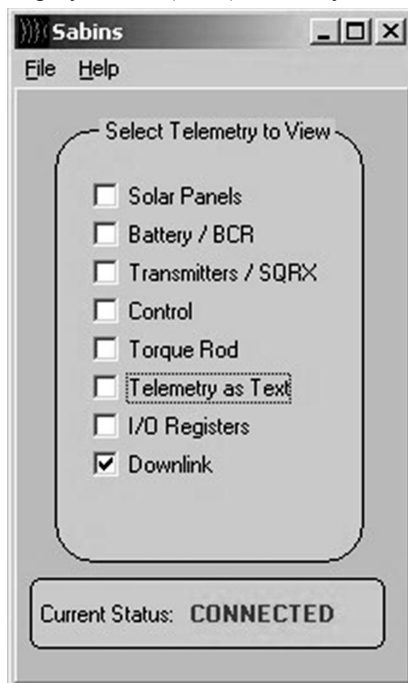


Figure 6: Sabins main menu - connected over TCP/IP.

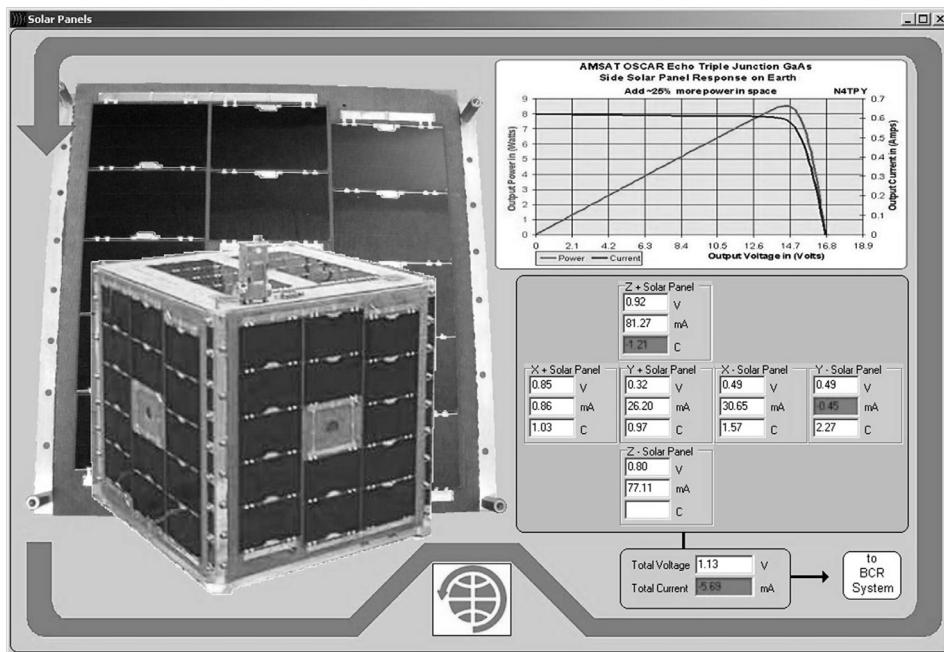


Figure 7: Sabins solar panel telemetry display.

over TCP/IP from the sound card modem. The sound card modem could easily send the same data at the same time to both Sabins and another telemetry program such as tlmEcho. Sabins receives the TCP/IP data, and tlmEcho receives serial port data over a hardware null modem cable between two serial ports.

A Picture is Worth a Thousand Words

If you want to get another Amateur Radio operator or a student interested in the telemetry, then you probably need more than a few columns of changing numbers. Displaying the telemetry as a series of numbers organized by the telemetry channel number is easy enough for the computer, but somewhat less interesting to the human. What do the batteries that we are measuring look like? What do the satellite radios look like? This battery control thingamajig, what does it look like?

As a telemetry display program, Sabins was written with the idea that the telemetry should be visually presented in context. Telemetry values for the solar panels should be displayed on a screen next to pictures of the solar panels themselves. Likewise, the telemetry values for the batteries should be shown on a page with pictures of the actual batteries that are in the satellite. (All photos are used with permission.) Hopefully, this puts the telemetry in context for the beginning telemetry student. For the hard core telemetry watchers, Sabins has another page available with just columns of changing

numbers.

But wait, there's more...

Sabins will receive the telemetry "live" over a TCP/IP connection from the sound card modem Willow or from a telemetry server on the Internet. The latter will allow you to watch live telemetry even if the satellite is on the other side of the world, as long as someone on that side of the planet is feeding the data to the telemetry server. The telemetry server project has recently been finished and is now ready for some large scale testing. If you're interested in participating, please contact me.

To review and analyze historical telemetry, Sabins can also read .KSS files (both flavors) and whole orbit data files (WOD files). When reading these files, you can "single step" through the telemetry file one packet at a time and watch the changes in each of the telemetry windows as that packet is decoded. Telemetry values that have changed since the last packet are colored white. Values that are outside the limits (as defined by the coefficients file) are colored red.

Okay, so how does this all work?

There are several ways to connect together all of the piece parts depending on what you want to do and how you want to process the resulting telemetry:

Method #1 - offline processing for standalone systems

This is a simple way to get the telemetry yourself. I used this method originally with just a nineteen inch piece of wire stuck



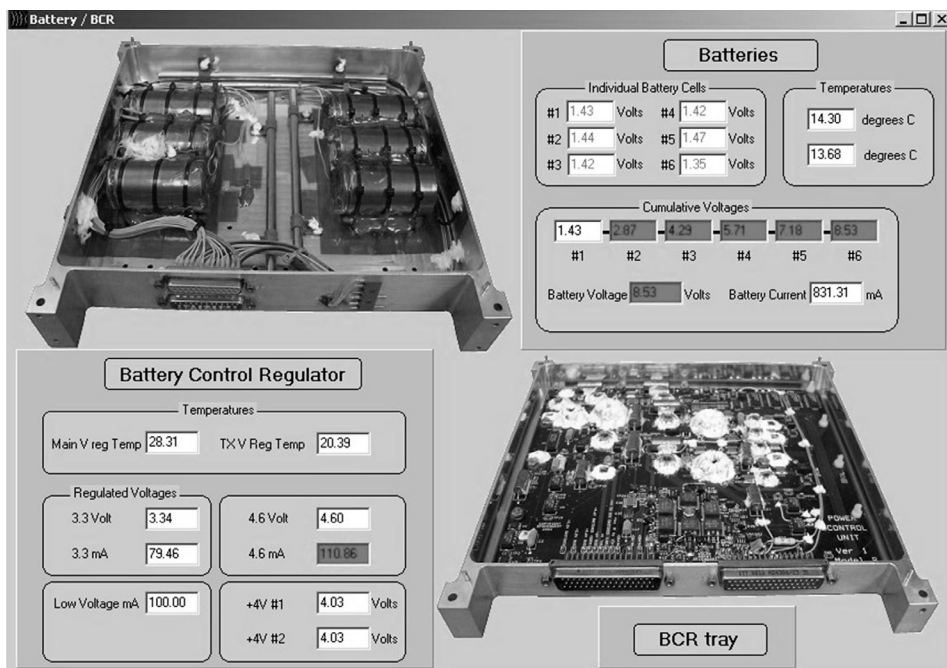


Figure 8: Sabins Battery-BCR telemetry display.

in the N-connector of a preamp on top of my car roof. The car's roof makes a nice ground plane. The preamp went to a scanner with the discriminator tapped and fed to the laptop sound card. The success of this method depends on several factors including the power output from the satellite and the elevation of the pass. Willow receives the audio, records the audio and demodulates the AX.25 packets. This works well if you have a very slow computer or you don't have Internet access, or you want to experiment with different modem settings. In the latter case, you can repeatedly tweak the modem settings on the same recording until you get the best results or the largest .KSS file. You can then use Sabins to display the telemetry from the .KSS file.

Method #2 - a "real time" receiver

Connect your receiver's discriminator output to your sound card and run Willow as your TNC and 9600 baud modem. Willow can send the received packets over TCP/IP to Sabins (in real time) as well as save the packets to a .KSS file for later analysis. You can also have Willow send the packets out up to two serial ports to other programs such as tlmEcho. In the near future, you should also be able to send the packets over the Internet to a telemetry server for distribution.

Method #3 - Real time but without a radio receiver (just Internet access)

Run Sabins and connect over the Internet to a telemetry server to watch the live telemetry (as long as someone somewhere

on the planet is in the footprint of the satellite and feeding their received telemetry to the telemetry server on the Internet.)

A Quick Start Guide for Willow and Sabins

1. Connect your computer's sound card input (microphone or line in) to your satellite receiver's discriminator output. You must take the output from the discriminator, not the speaker audio. Turn on the radio.
2. Download Willow and Sabins from <http://www.quagliana.com/willow>. You will also need the latest echocof.csv file. Unzip the zip file containing Willow and Sabins. Put both executables from the zip file and the echocof.csv file into the same folder.
3. Start Willow by double clicking on the icon. You should see a large white window (the "Demodulated Data" window) where packets will be displayed (Figure 1). On the bottom left is a signal quality meter showing how well the signal is being demodulated. It is not an S-meter measuring signal strength. Instead, it takes into account the number of good characters and HDLC flags that are being received relative to the total number that could have been received. Below are LEDs for data carrier detect (DCD), for a connection on the first and second serial ports (CONa and CONb) and for a connection over TCP/IP (COMip) (Figure 2).

4. On the bottom middle is an eye diagram (Figure 3) that can be turned on or off using the checkbox below it. To the bottom right are various options you can change (Figure 4), and on the right middle is a window showing the number of good and bad packets from various callsigns (Figure 5).
5. Assuming that you want to run Willow "live" using audio from your sound card (not from a recording), you need to first turn on the sound card within Willow. Click on "File" on the main menu and then click on "Activate Soundcard" to start the sound card.
6. The audio input levels are crucial for 9600 baud reception. You will need to adjust your computer's audio levels until you see "Audio OK" in green in the bottom center. If you see "No Audio" or "Too Loud" then you need to make adjustments. To make the adjustments in Windows XP, click on the Windows "Start" button, then "Run", then type in "SNDVOL32" (without the quotes) and click on OK. This will bring up the Volume Control. In the Volume Control click on "Options" then "Properties" then click on "Recording" then click on OK. You should now see the vertical slider bars. Verify that you have selected the correct recording device by placing a checkmark in the "Select" checkbox. This will probably be "Microphone" but might be "Line In" depending on where you plugged in the cable from your receiver's discriminator. To make coarse adjustments, click on the slider bar with the mouse. To make fine adjustments, click once on the slider bar to select the slider bar, then use the up and down arrow keys on the keyboard to slowly move up or down. You can watch the audio indicator or the eye diagram while you do this. You want the audio to almost always say "Audio OK" but a "Too Loud" indication only once in a while is probably fine. If the eye diagram checkbox is checked but you still only see a flat line and Willow only says "No Audio" recheck your cables and recheck which device is selected in SNDVOL32.
7. If you think you have the audio levels adjusted correctly, try a test. Verify that you have told Willow to display the packets -- on the "Display" tab in the lower right, check the box for "Display

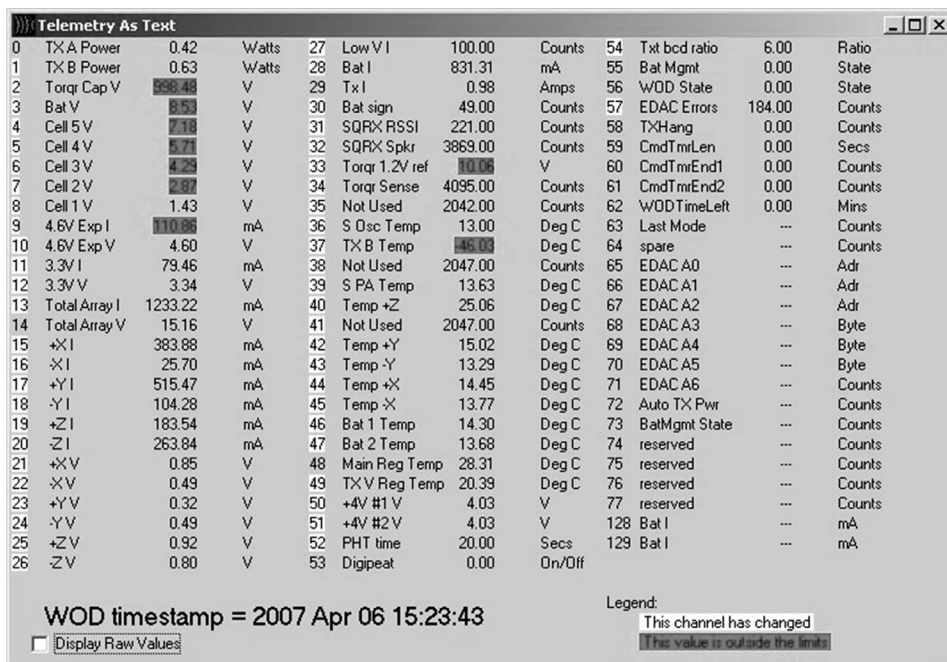


Figure 9: Sabins display telemetry as text.

- packets in TNC2 style.” (Figure 2) Then send a 9600 baud packet from another radio to your satellite receiver. You should see it displayed on the “Demodulated Data” window. (Hint: One easy way to do this is for you (or a friend) to send a 9600 baud APRS packet from an HT, but there are lots of ways.) If everything works, you should see your packet in the “Demodulated Data” screen.
- Next, tell Willow to send the received packets out over TCP/IP. In the lower right corner, click on the arrows to scroll through the option pages until you see “TCP/IP.” Click on “TCP/IP.” On the “TCP/IP” page put a check in the box next to “Send DATA to TCP/IP port.” The other options should be left as “localhost” and “41041.” [4] If you get a warning from Windows or your firewall program, then you will need to tell it to “Unblock” Willow to allow TCP/IP.
 - You should now see a green LED on the lower left for the connection over IP (“CONip”) and in the “Demodulated Data” windows you should see “Starting TCP/IP Kiss server on port 41041.” (Figures 1 and 2)
 - Now that you have Willow working, you need to start up Sabins.
 - Once Sabins start, click on “File” then “Connect to TCP/IP modem.” The “Current Status” in Sabins should change to “CONNECTED.” (Figure 6)

- In Sabins, click on the checkbox next to “Downlink” to see the packets that Sabins is receiving. You should see “Trying to connect to local KISS modem over TCP/IP port 41041.” and then “Connected.”

You’re ready! As Willow receives packets via the sound card it will send them to Sabins. You can display other telemetry pages in Willow by checking the box next to the name of that window.

The future - what could we do?

Years ago, when AO-40 was active, you could start up P3t or another telemetry program and watch live satellite telemetry, even if the satellite was over a different part of the planet, as long as someone somewhere was receiving that telemetry and feeding it to the telemetry server. Let’s do that again, but this time let’s not just do it for one satellite. Worldwide live telemetry for multiple satellites should be possible. If there’s a telemetry ground station with Internet connectivity then we should be able to watch telemetry live. Telemetry ground stations could be as simple as a small antenna, a radio and a shoe box sized appliance computer with a sound card and an Ethernet jack. A dozen of these scattered around the planet should provide nice coverage. Then, from home, you could start up your telemetry program in a manner similar to Firefox’s “Open in tabs” and we could see live telemetry and status updates for all the satellites we want.

Thanks

My thanks to Gould Smith, WA4SXM, for encouragement and whole orbit data telemetry for testing. And of course, thanks to my wife, who assisted in the preparation of this work.

I am continuing to develop and improve the modem and telemetry program. Comments, criticisms, questions and suggestions for improvement are all welcome. I hope this soundcard modem will encourage others and generate further interest in digital signal processing as well as telemetry collection using simple ground stations.

See you on the birds!

Further Reading

Smith, G. Gould. “AO-51 Development, Operation and Specifications.”

- For a hardware version of the peak detectors, see the 9600 modem by John Magliacane, KD2BD, at <http://www.amsat.org/amsat/articles/kd2bd/9k6modem/9k6modem.html>
- For a complete description of the G3RUH modulation format see “The Shape of Bits to Come” by James Miller, G3RUH, available at http://www.amsat.org/amsat-new/archive/articles/James_Miller/txt/108.txt.
- The Sabin is a unit of measurement for how well a substance absorbs sounds and echoes. Sabins is the name of the program that displays the telemetry measurements from the Echo (AO-51) satellite.
- The TCP/IP port number is a numeric pun. Decimal 41041 is hexadecimal A051. ☺



Please support AMSAT-NA.
Thanks!





AMSAT-UK Colloquium 2009

This year the AMSAT-UK International Space Colloquium will be held from **Friday, July 24 to Sunday, July 26** at the **University of Manchester** right in the center of the city and within 200 meters of Piccadilly Railway Station. The station has direct trains to Manchester Airport and there is also an hourly bus service from the Liverpool John Lennon Airport.

This 3 day event attracts an international audience of those involved in building and operating Amateur Radio satellites and CubeSats. Details of this and previous events can be found at: <http://www.uk.amsat.org/colloquium>

AMSAT-UK invites speakers, about Amateur Radio space and associated activities, for this event. They are also invited to submit papers for the "Proceedings" document that will be published at the same time, but printed papers are not mandatory. We also welcome "unpresented" papers for the Proceedings document. Offers of talks should be submitted as soon as possible. The final date for full documents to be received is late June so that the "Proceedings" document can be available to participants. Submissions should e-mailed to: david.johnson@blackpepper.co.uk

The new RSGB GB4FUN radio communications trailer, which has a fully equipped satellite station, will be available during the event for visitors to work the satellites. The event is open to all radio amateurs and SWL's. Either day passes or full packages comprising overnight accommodation and meals are available.

The AMSAT-UK Colloquium Web page is: <http://www.uk.amsat.org/colloquium>

AMSAT is the North American distributor of **SatPC32**, a tracking program designed for ham satellite applications. For Windows 95, 98, NT, ME, 2000, XP, Vista.

Version 12.8 has improved Windows Vista compatibility and enhanced support for tuning multiple radios.

Version 12.8 Features:

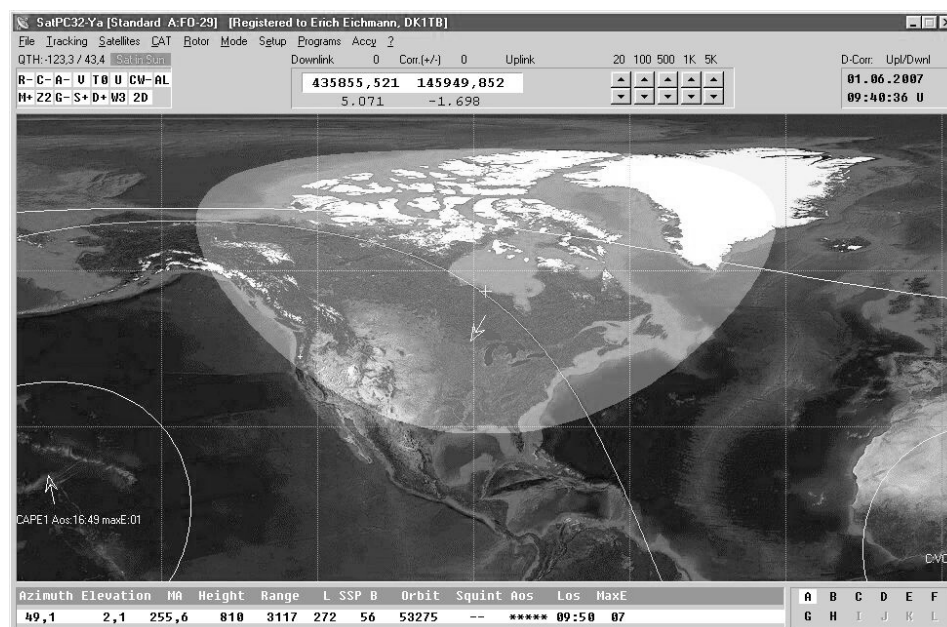
- Select 2D/3D map with a single mouse click
- Select Political/Physical map with a single mouse click
- AOS voice announcement
- Countdown program displays next AOS of your favorite satellites
- Automatic Internet download of Keplerian elements.
- Graphical tracking on a world map with two selectable Zoom factors.
- One-click satellite switching using 12 "letter" buttons.
- Automatic rotor control support for: LVBTracker, Kansas City Tracker/Tuner, FODtrack, Uni_Trac, SatEL, Labjack U12/U3/Piggyback, W0LMD Mini/Junior/Senior Trackers, Yaesu GS-232, ARS from EA4TX, EGIS rotors, IF-100, RIF-PC, AMSAT-DL interface, WinRotor32, HalloRotor, and WiSP DDE clients.
- Doppler tuning with on-screen frequency displays. Radio models supported:
 - Yaesu FT-847, FT-736R, FT-817, FT-857, FT-897
 - ICOM IC-820H, IC-821H, IC-910H and other ICOM radios
 - Kenwood TS-790 and TS-2000
 - DDE client programs
- "Transparent" VFO-knob tuning in addition to keyboard and mouse tuning.
- "Virtual" VFO tracking for half-duplex transceivers FT-817, FT-857, FT-897, IC-706 and IC-7000.
- Includes a special version for ISS split-frequency operation.
- Controls subaudible tone on FT-847, FT-736R, FT-817/857/897, TS790A and IC-910H.
- Includes a non-graphical version and programs that output lists to the screen, printer, or a file.
- Interfaces with WiSP, with user-defined satellite switching priority.
- Includes a separate program for tracking the Sun and Moon.

Price is \$45 for AMSAT members, \$50 for non-members, on CD-ROM.

A demo version may be downloaded from <http://www.dk1tb.de/indexeng.htm>

A registration password for the demo version is \$40 (members), \$45 (non-members). Order by calling 1-888-322-6728.

The author DK1TB donated SatPC32 to AMSAT. All proceeds support AMSAT.





LVB Tracker Box

- Reasonably priced and all profits go to AMSAT
- USB or serial interface
- Ethernet interface capable
- Open software
- Open architecture
- Built-in rotor interface cable with DIN connector
- Power supplied via the rotor controller cable
- Bi-directional interface allows the unit to read the rotor position
- LCD position readout
- Front panel manual control
- Self-programmable, allows for easy software upgrades
- Supported by the major tracking programs
- Uses GS-232A or Easycomm I/II protocols

Contact Martha at the AMSAT office 301-589-6062 to order.

The complete units will be built in groups, so get your orders in early.

Units will be shipped as they become available.

- 1) Bare board - \$20 + S&H - no parts kits available
- 2) Populated board, serial interface - \$100 + S&H - no kit with USB unit, rotor cable and LCD available, we do have a parts list with recommended part numbers and sources.
- 3) Custom Ten-Tec Enclosure powder coat, silk-screened, drilled/punched - \$50 + S&H
- 4) Complete unit - board, USB output, rotor cable, LCD, enclosure - \$200 + S&H **our most popular

Documentation for the LVB Tracker can be found at: <http://www.LVBTracker.com>

Boards and complete units may be ordered from the AMSAT office at 301-589-6062 or from martha@amsat.org

The Classroom Satellite

Used by NASA, the U.S. Air Force Academy, and institutions around the world to give students and working professionals hands-on experience with satellites.

"I've been controlling satellites with reaction wheels for 20 years - now I really understand how they work!" - NASA Engineer

Find out more at <http://www.EyasSat.com> !

YOUR SATELLITE ANTENNA SOURCE

NEW! Ultra-gain!

436CP42-U/G
42 elements,
18' 10" tapered boom
(pair with 2MCP22)

436CP30
30 elements,
9' 9" boom
(pair with 2MCP14)

2MCP14
14 elements'
10' 6" boom

2MCP22
22 elements,
18' 6" boom

EB-144 & EB-432
Eggbeaters,
see 9/93 QST

- Stacking frames
- AZ & EL positioners
- Fiberglass crossbooms
- Power Dividers
- Phasing harnesses

M² 4402 N. Selland
Fresno, CA 93722
(559) 432-8873 FAX: 432-3059



What's Inside An Antenna Rotator?

by Peter Carr, WW3O, wb3bqo@localnet.com

The antenna rotator that spins my satellite array stopped working the other day. The unit was made by Radio Shack (RS) and had been installed about two years ago. It replaced a RS unit that had lasted eight years. The antenna array is the same one that the old rotator had spun so I was curious about why this one had quit.

The unit is divided into three parts. There is the top rotating section which has a rubber shield, heavy shaft and main gear. The second section is the gear plate (Figures 1 & 2). The plate holds three gears that reduce the electric motor speed down to 1 RPM while offering braking to prevent wind driven rotation. The third section is the electric motor with a three-wire terminal strip.

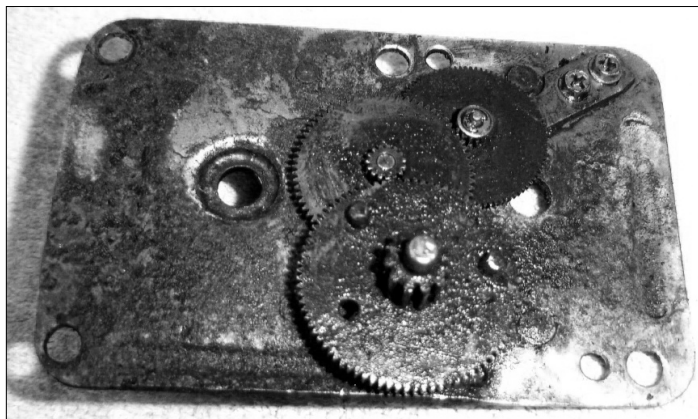


Figure 1: This is the gear plate top view. The motor connects through the bottom and the main gear connects from the top. It is very rusty from water leaking down from the top bearing.

Disassembly is done by first removing the bottom door. It can be pried off the two studs on the inside of the housing and laid aside. There are two press-on nuts that hold the terminal strip (Figures 3 & 4, see next page) to the posts. These can be pried off and saved for reassembly. Next, two screws that hold the motor to the plate are removed. Now the motor and terminal strip can be laid aside.

It is now easy to see the bottom of the main shaft which is retained by a split ring. I used a borrowed pair of split ring pliers to remove the ring and the two thin washers underneath. Once the split ring is removed the whole top of the rotator can be raised up from the housing.

I used a 3/8 inch socket and driver to remove four screws from the gear plate. The plate now can be removed from the housing. On inspection it was evident that the shafts of the gears were severely corroded and had

stopped moving.

I inspected the main gear and found several teeth were worn off. The damage was from wind buffeting since the teeth were not broken. I had normally parked the array against the "north stop". This is where the damage seems to have occurred.

The damaged gear (Figures 5 & 6, see next page) was not due to corrosion, but all the rest of the trouble was caused by water. The source was the rubber shield above the top bearing (Figure 7) that had a very loose fit. This allowed water to pass the shield and enter the top bearing. There did not appear to be any grease in the bearing so the water dripped down onto the top of the gear plate. The gears on the gear plate kept

most of the water from damaging the motor. There did not appear to be any grease on the three gears of the gear plate so they stopped turning.

The unit was clearly beyond repair. Parts, such as the main gear, are not available. The small diameter rod that holds the main gear onto the shaft is welded in place. It

might be possible to use a small grinding wheel to free the rod but it would be difficult since the gear is too big to be removed from the top of the housing. The whole rotator and its companion control unit are less than \$100 so it was better to just replace the whole thing.

Now that the obvious faults have been identified, it's easy to service a new unit so the same thing doesn't happen again. First, after disassembly, lots of axle grease should be added to all the gears and the top bearing. A small amount should be added to the gear on the output of the electric motor

as well. Once you are satisfied that all the gears are well lubed, you can reassemble the unit. Next, be sure the rubber shield is seated above the main bearing. Then use silicon rubber adhesive to seal the gap between the inside of the shield and the housing top unit. It might be a good idea to coat the inside lip of the rubber shield with grease to ease the drag on the edge of the bearing. Once you check that there are no "spare" parts and all the nuts and bolts are tight you can go ahead and reinstall the bottom door.

Earlier I mentioned the main gear wear due to wind damage. I had usually set the array against the north stop when not on the air. Both satellite antennas are end-mount units with a balance boom off the rear of the array for mechanical balance. This means that wind load is nearly all in front of the rotator. Most of our winds come from the west and northwest so I plan to stop the array in the east or southeast in the future. This would reduce the load on the gears and possibly prevent damage to the main gear.

The Radio Shack antenna rotator is a good unit. In use with the typical satellite antenna combination it should give many years of reliable service. If the proper lubrication is applied to the gears and the rubber shield is properly sealed, the unit should have a long and useful life. ☺



Figure 2: The gear plate bottom view. Two screws hold the motor down while the terminal strip is attached to the two posts.

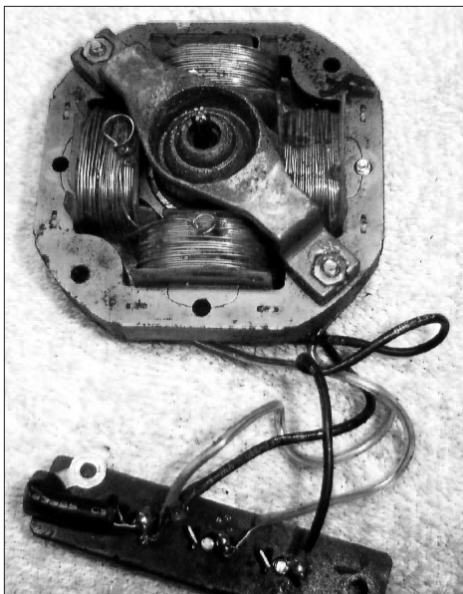


Figure 3: The motor and terminal strip. Since this is on the bottom of the gear plate it was protected from water and rust.



Figure 4: The motor and terminal strip top view. The unit is in nearly new condition compared to the gears.



Figure 5: The top part of the rotator pulled up from the housing to expose the top bearing. There is little grease and a sloppy fit which passes water down onto the gear plate.

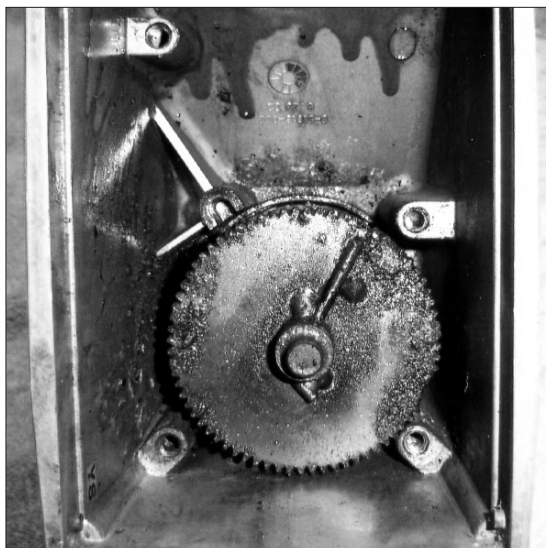


Figure 6: The main gear is quite corroded and has teeth missing at the 4 o'clock position in the picture. The rod that attaches the gear to the shaft and is welded in place is also visible.



Figure 7: The top bearing of the housing and the top of the rotator are shown. The rubber shield does not prevent water from entering the bearing and corroding the gear plate.

First CW and FM Signals Produced for SuitSat-2

by Gould Smith, WA4SXM, wa4sxm@amsat.org

Over the weekend of 3-5 April, a number of SuitSat-2 team members met in Phoenix at the Microchip complex to work on the electronics and software. The screen capture shown in Figure 1 shows the first signals generated by the IHU, sent to the SDX, modulated and sent out the 2 m transmitter. The signal in the highlighted area is the FM signal and the signal to the left of the FM audio is the CW signal (you can see the dots and dashes in the waterfall display).

It was a long, but very productive weekend. Figure 2 shows some of the group hunched over their computers, oscilloscope and SDR IQ trying to produce the signals shown in Figure 1. Left to right are Tim Moffat, Jim Johns, Lou McFadin, Tony Monteiro, Bill Reed, Steve Bible, Joe Julicher and Jerry Zdenek.

Tim Moffat has created a Web site for SuitSat-2 where we will be placing additional information, photos and wave files. URL: <http://www.suitsat2.org>

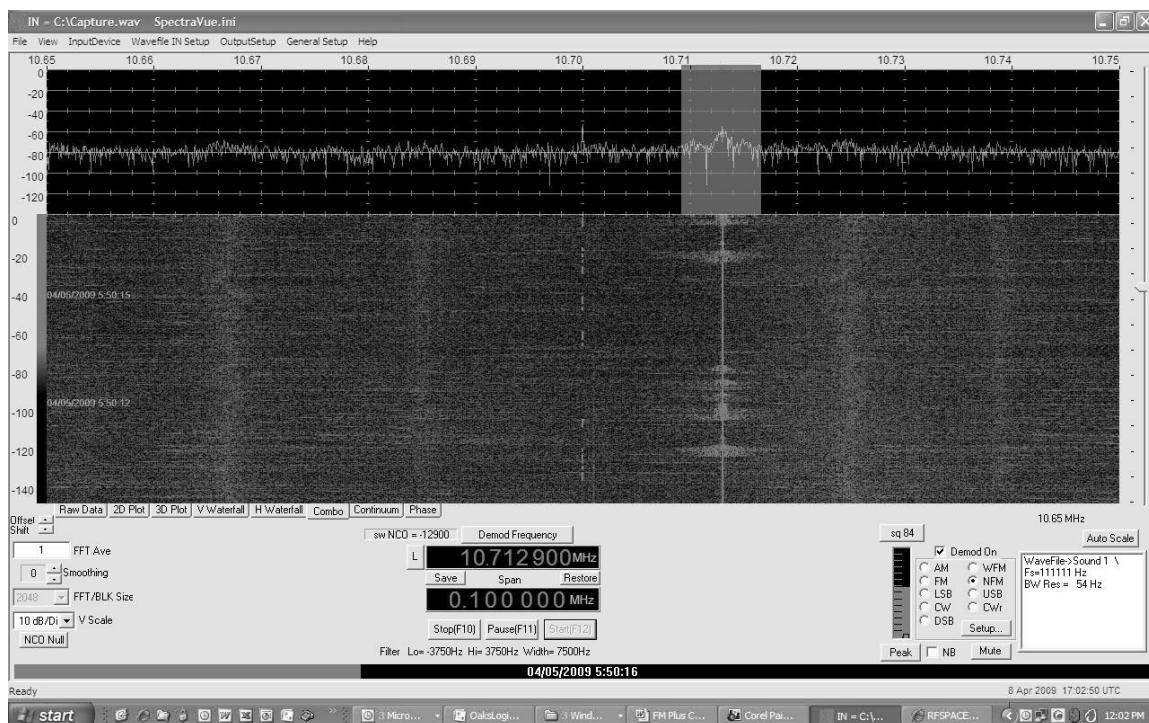


Figure 1



Figure 2

Help Wanted AMSAT needs qualified volunteers for a number of positions!

If you want to be a part of the solution in making AMSAT operational and work toward designing, building and finding a launch, WE NEED YOU!

No pay for 5+ hours per week, but a great deal of satisfaction in knowing you are helping make something happen.

We need people with these skills:

- Marketing
- Sales
- Software engineering
- Hardware engineering
- PC based software design
- Web design and maintenance
- Project management
- Documentation
- Hardware testing
- Software testing
- Hardware prototyping
- Specific area Web site information maintenance
- Video recording, digital conversion and editing
- Write technical or instructional material
- Educational activities
- Promoting AMSAT as an Area Coordinator



and any other area you think you think you can make a difference.

We often have people volunteer, but many don't deliver on their promises. So, pick an area that you think needs improvement and explain what you will do to make it better. Then do something to show that you can follow through.

Send your suggestions, actions plans and a description of why you are capable of doing this task to Gould Smith, WA4SXM, wa4sxm@amsat.org

The AMSAT Store (see www.amsat.org) is back online! Here is a new AMSAT product.

AMSAT 10' locking carpenter's
tape \$5



AMSAT® President's Club! Join Now!

Contribute to **AMSAT®** directly through easy, automatic charges to your credit card.
Donations may be USA tax deductible. (Check with your tax advisor.)

Titanium Donors contribute at least US \$400 per month.

Every **Titanium Donor** receives gifts of:

- ✓ Everything at the Platinum Donor Level, PLUS:
- ✓ A very special, *hand crafted*, AMSAT President's Club Donor's pin.

☐ \$400 / month

☐ \$4800 one time

Platinum Donors contribute at least US \$200 per month.

Every **Platinum Donor** receives gifts of:

- ✓ Everything at the Gold Donor Level, PLUS:
- ✓ A very special, *hand crafted*, AMSAT President's Club Donor's pin.

☐ \$200 / month

☐ \$2400 one time

Gold Donors contribute at least US \$100 per month.

Every **Gold Donor** receives gifts of:

- ✓ Everything at the Silver Donor Level, PLUS:
- ✓ A personal invitation to the AMSAT Dayton dinner (free).

☐ \$100 / month

☐ \$1200 one time

Silver Donors contribute at least US \$50 per month.

Every **Silver Donor** receives gifts of:

- ✓ Everything at the Bronze Donor Level, PLUS:
- ✓ A personal invitation to a reception with the AMSAT Directors, Officers and project designers and builders (free).
- ✓ Annual endorsement sticker after each year of donation.

☐ \$50 / month

☐ \$600 one time

Bronze Donors contribute at least US \$25 per month.

Every **Bronze Donor** receives gifts of:

- ✓ A unique "AMSAT President's Club" certificate.
- ✓ A specially designed AMSAT President's Club Donor pin.

☐ \$25 / month

☐ \$300 one time

Core Donors contribute at least US \$10 per month.

Every **Core Donor** receives gifts of:

- ✓ A specially designed AMSAT President's Club Donor pin.

☐ \$10 / month

☐ \$120 one time

Choose where your contribution should go:

☐ AO-Echo ☐ AO-Eagle ☐ ARISS ☐ Future Projects ☐ General Fund

☐ RENEW my
President's Club
AUTOMATICALLY
every year!

☐ I prefer to make my donation in one yearly payment of \$ _____.

(Credit card only, please.)

THANK YOU!



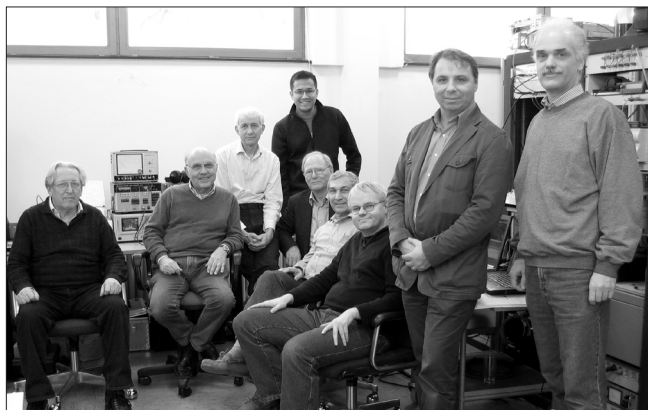
Press Release – AMSAT-DL

First German Mars Mission Makes a Sidestep to Venus

Marburg, 27 March 2009

Ground station in Bochum generates echoes from Venus

On 25 March 2009 the team of German Space Agency AMSAT-DL members reached another milestone on the way to

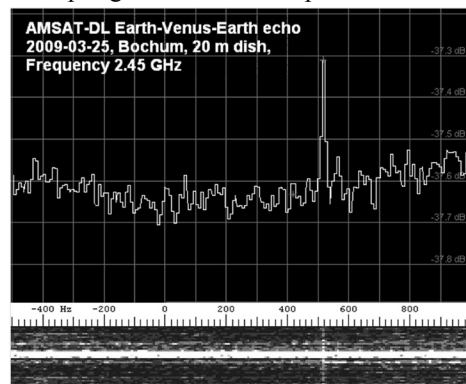


The international team lead by AMSAT-DL included the following members (L-R): Hermann Hagn, DK8CI; Karl Meinzer, DJ4ZC; James Miller, G3RUH; Achim Vollhardt, DH2VA; Max Münich, DJ1CR; Freddy de Guchteneire, ON6UG; Wolfgang Büscher, DL4YHF; Michael Lengrüsser, DD5ER; Hartmut Päsler, DL1YDD.

send a spacecraft to Mars. From the ground mission control station in Bochum (located in the observatory IUZ Sternwarte), radio frequency signals were sent to Venus. After nearly 100 million kilometres of track and approximately five minutes term, the transmissions returned as echoes from the Venus surface and were received in Bochum. This was the first German success with receiving RF echoes from another planet.

The transmitter technology for the planned AMSAT-DL Mars mission was the last key component tested and it has passed the test.

AMSAT-DL is preparing for the first privately financed flight to Mars and is attempting to meet the next possible launch



The received echo from Venus.

window. This spacecraft is intended as a scientific and communication platform. In the last few years research done by AMSAT-DL has developed and tested all essential components for this spacecraft. Many technical elements were successfully tested on satellites in Earth orbit. With reception of

its own echoes from Venus the ground command station is ready for operation and the AMSAT-DL team is waiting in the wings to construct the spacecraft.

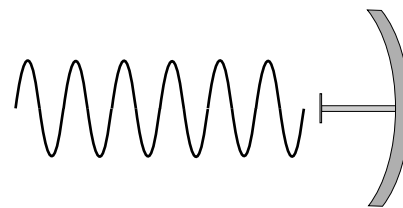
Development, design and construction of this first German Mars mission have been achieved through the work by AMSAT-DL and its partner organizations. Already a third of the total project costs have been performed. More work will be completed by volunteers during the mission. To

finance the specific construction costs and the launch costs, AMSAT-DL is working to obtain the financial support of the DLR (Deutsches Zentrum für Luft- und Raumfahrt). The funding requirement is 20 million Euros.

AMSAT-DL would like to demonstrate that their approach to low-cost space missions is feasible. In comparison, the ESA and NASA missions to Mars have cost ten times as much.

The Mars mission is utilizing the open source principle. Private donors can contribute to the mission. A Web site has been set up for Mars tickets <http://www.ticket-to-mars.org>. Anyone can buy a ticket to Mars for 50 Euros.

The open source principle allows everyone to receive live mission data during the flight to Mars. This is possible by using Amateur Radio frequencies and a receiver with a 1-meter diameter dish. If this type of equipment is not available it is also possible to download a live stream via the Internet. All necessary information will be disclosed before the mission.



Background information

AMSAT-DL is an association of engineers, technicians, scientists, Amateur Radio and space enthusiasts who have over the past 30 years accumulated experience in satellite development, construction and operation.

References

AMSAT-DL: <http://www.amsat-dl.org>

Mars-Mission: <http://www.go-mars.org>

Ticket-to-Mars: <http://www.ticket-to-mars.org>

Venus transmission: http://www.amsat-dl.org/index.php?option=com_content&task=view&id=165&Itemid=97



Project leader of AMSAT-Mars-Mission, Prof. Dr. Karl Meinzer, DJ4ZC, holding the feed horn for 2.45 GHz installed at the IUZ Sternwarte Observatory in Bochum.

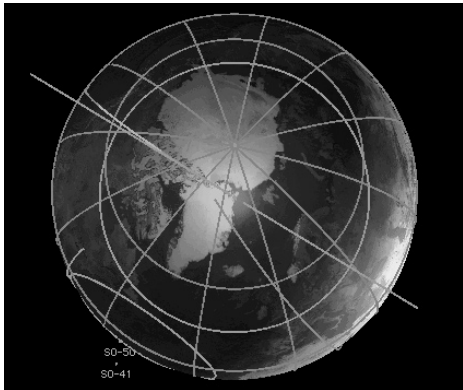


The 20 meter dish at Bochum.



MacDopplerPRO X

The premier Satellite tracking and station automation application for the Macintosh - OS 9 & OS X



MacDoppler for Cocoa gives you a seat right in the heart of the Operations & Command Centre for every satellite in orbit, providing any level of station automation you need from assisted Doppler Tuning and Antenna Pointing right on up to a fully automated Satellite Gateway !

It will calculate the position and relative velocity of the satellites you are tracking and automatically adjust the Doppler shift on both transmit and receive as well as pointing your antennas with predictive dead spot crossing so that a pass is never interrupted.

A Universal Binary that runs native on Intel and PPC Macs and provides separate panels for the map (2D or 3D), the radio and rotor controls, a sorted table of upcoming satellite passes and a Horizon panel that graphs upcoming passes as a function of elevation over time.

Now available at a special member discount price from AMSAT !

martha@amsat.org
850 Sligo Ave.,
Silver Spring MD,
20910-4703 USA.

(301) 589-6062, (301) 608-3410 (Fax)

Dog Park Software Ltd.
www.dogparksoftware.com

Do you still use manual tuning to remove Doppler changes? Why not automate?

Uni-Trac 2000 will automatically tune your Receiver (and Transmitter) to compensate Doppler frequency changes. Uni-Trac will also STEER your Antenna !

Uni-Trac 2000, including Interface Cable \$280.00
FOB Concord, Mass. 01742, USA.



Spectrum International, Inc.,
P.O. Box 1084,
Concord, Mass. 01742, USA.
Tel: (978) 263-2145
Fax: (978) 263-7008

SSB ELECTRONIC USA

PHASE 3D Equipment Headquarters

SSB Electronic USA features world class VHF - UHF - SHF equipment. The latest gear from: SSB Electronic, Kuhne Electronic - DB6NT, M2 Antennas, Beko Electronic, EME, Procomm, AIRCOM PLUS, AIRLINK, ECOFLEX and WINRADIO is available.

- Mast Mounted Preamplifiers 144 - 2400 MHz.
- Ultra Low Noise LNA's 50.0 MHz. 24.0 GHz.
- Transverters 50 MHz. - 24.0 GHz.
- Antennas - Rotors
- Downconverters and TX Upconverters for all P3D frequencies
- Mode "S" Downconverters
- Mode "L" TX Upconverters
- Linear Amplifiers 50 MHz. - 24.0 GHz.
- Ultra Low Loss Coaxial Cable
- Transverter Kits 1.2, 2.4, 5.7 & 10 GHz.
- Parabolic Dishes

So What's New ?

BEKO Electronic: 144 MHz. - 1296 MHz. Linear Amplifiers 100 Watts - 1200 Watts

DB6NT Electronic: MKU 24 OSCAR Mode "S" Downconverter IF 144 or 432 MHz.
MKU 10 OSCAR 10.451 GHz. Down Converter
MKU 24 G2 OSCAR 2.4 GHz. Transverter 1 Watt
MKU 57 OTX 5.6 GHz. OSCAR TX Upconverter *plus more.....*

ECOFLEX - LLC Super Flexible Low Loss Coaxial Cable

SSB Electronic: UEK-3000SAT Mode "S" Downconverter IF 144 or 432 MHz.
UTM-1200 DLX Mast mounted 1269 MHz. 15 Watt TX Upconverter
UTM-1200-1 1269 MHz. 1 Watt TX Upconverter
SP-2000 & SP-7000 Heli-Filtered Mast-Mounted Preamps *plus more.....*



SSB
Electronic USA

For complete specifications and prices, please visit our WEB SITE: www.ssbusa.com

Phone 570-868-5643

New Hours: MTWTFSS
9:00 AM - 11:00 PM

124 Cherrywood Dr.
Mountaintop, PA 18707



Two Generations of Hams in Space

by Owen K. Garriott, W5LFL, NASA Astronaut retired and Richard Garriott, W5KWQ, Cosmonaut/Astronaut
First American father-son pair to travel in space. Owen is an Eminent Member of HKN.

NOTE: This article also appears in *The Bridge*, the magazine of Eta Kappa Nu, Spring 2009.

By Owen K. Garriott, W5LFL

Back in about 1944 toward the end of WW II, my father (also Owen Garriott) came home one evening and asked if I would like to attend an evening “radio theory” class with him and a dozen or so other adults. Pleased, but also a bit intimidated, I looked forward to participating with my father in a new and interesting activity. Scrolling ahead a year or so, and also having completed a code class (13 words per minute were required in those days), we both had passed our ham license examinations and received call signs W5KWQ (my father) and my still current call, W5LFL. Little could we imagine where this small start might lead our family!

First came a job throughout high school at our local AM radio station as an FCC licensed engineer and control operator. The chief engineer was another ham, of course. Then off to college at the University of Oklahoma majoring in electrical engineering (EE) and then a three year commitment to the US Navy with collateral responsibility as the electronics officer on a destroyer at sea. But there was a desire for further graduate education, so after resigning my commission, I was accepted as a graduate student in the Radio Propagation Laboratory at Stanford University, where it turned out, many EE faculty members were also licensed hams.

Preparation for the International Geophysical Year (IGY) was underway in 1956 and radio propagation was a major study area. By the following year I was looking for a research topic for a dissertation when what should be heard around the world on October 4, 1957 but a “beep-beeeep” transmitted from the world’s first artificial satellite, Sputnik I, on 20 and 40 MHz. And studies of radio transmissions through the ionosphere became that needed research topic for me.

Another important milestone came a few years later after receiving a post-doctorate fellowship from the National Science Foundation for one year of study at Cambridge University in England. While there, our third son (Richard) arrived. He still holds dual citizenship today, though he lived

in the UK only a matter of months in 1961. We then returned to the faculty at Stanford for more research and teaching.

In about 1963 I heard that NASA was considering the selection of flight crewmembers with research back grounds and not requiring years of jet test-flight experience. In fact, those accepted would be given a whole year of jet schooling with the USAF to qualify us in the T-38. In hindsight the Astronaut Office wanted to make sure that these “fuzzy haired” scientists (mostly with standard crew-cuts of the day) could actually be taught to fly jets safely and successfully, while we were greatly pleased

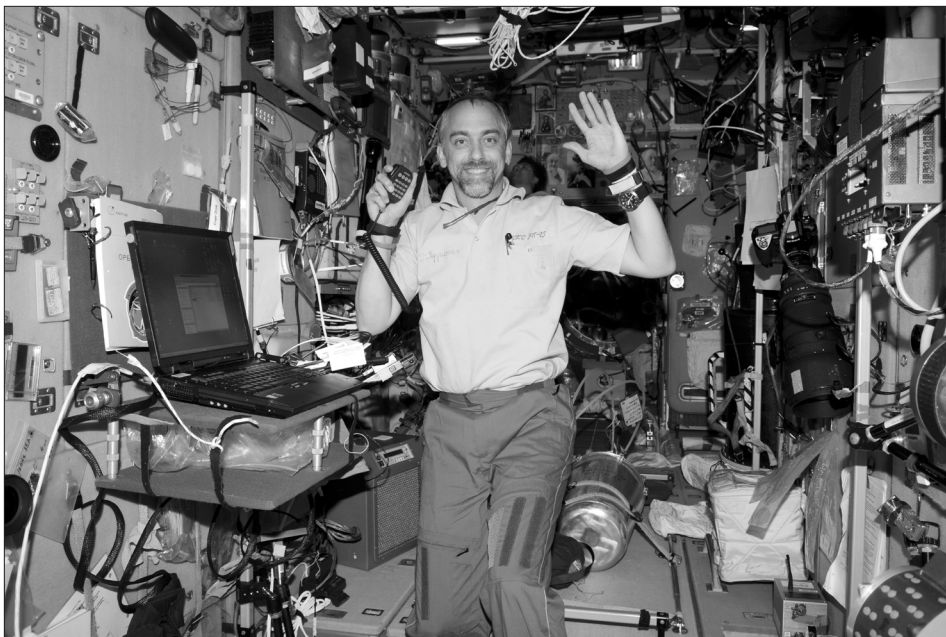
to find that we were to be given this training! The three of us without jet experience all graduated on schedule and some (in the second group of Scientist Astronauts) led their entire classes in both academics and flying skills. We then continued to fly the T-38 regularly for the next 20 years.

When back to the Astronaut Office in 1966 we all made some contributions to various Apollo missions. One of us, the geologist Jack Schmitt, went to the moon on Apollo 17 and the other three of us flew on each of the long duration Skylab missions. The Skylab flights were all world record durations at the time of about 1, 2 and 3 months in space.



AP Photo

This AP photo was first published on 10/25/08, the day after Richard, W5KWQ, landed in remote Kazakhstan. It was taken only minutes after his landing and extrication from the Soyuz capsule along with his two companion Cosmonauts. He is met and congratulated by his father Owen, W5LFL. Richard is obviously feeling great after 12 days in weightlessness! His dad reports this as one of his favorite photos of all time.



Richard's high altitude ham shack.

Much of this activity has been chronicled in a recent book "Homesteading Space" describing the whole program from the crew members' perspective. On my own two month flight we tried to get approval to take a ham transceiver on board, but approval was not forthcoming for several reasons. Waiting patiently, my next flight opportunity came in 1983 on STS-9/Spacelab-1. With a lot of help from the ham community we were approved to take a modest hand-held transceiver along and I had the privilege of operating the first ham station in space. [1]

But what was son Richard, all of 12 years old at the time of Skylab, doing in these years?

By Richard Garriott, W5KWQ

During my youth, when my father would come home from work at NASA, it was common for him to retire to his study and continue his work or research. This would occasionally include firing up his ham radio equipment and speaking with people around the globe. Thus was my introduction to Amateur Radio. But dinnertime discussions were most often wide ranging, from space activities to science experiments on orbit and even business opportunities that might become possible.

Throughout my school years I was an inveterate competitor in science fair projects. In my last two years of high school I sought a sufficiently challenging subject and one that preferably took advantage of my burgeoning computer skills as the field of computing was still quite new, and I had many self taught years under my belt, unlike most other high school students of the 1970s. Studying the propagation of radio waves in the ionosphere

with computer ray tracing seemed natural. I could get the fundamental science from my father, and apply my new skills which few HS students would have. This project which I continued for two years brought me International Science Fair awards and furthered my knowledge of radio wave propagation.

Also in my teen years I became devoted to finding my own way into space, after a NASA flight physician told me that my poor eyesight would prevent me from becoming a NASA astronaut. When 30 years later I finally appeared on the threshold of making this dream a reality, ham radio was an early consideration. I knew that I would be flying to the ISS on the 25th anniversary of my father's first ham transmission from space, and so I would not want to miss the opportunity to reverse the call! To that end, not only did I immediately go out to secure my own ham license, but then sought out my grandfather's call sign W5KWQ.

Ironically, the very reason that provoked me to consider alternate paths than NASA to reach space now became an experimental area that I could advance for NASA. Corneal surgery (PRK, or photorefractive keratectomy) was recently approved for astronaut candidate selection, but no one in the corps has had this surgical modification as they could not have been selected. Except that I had done it years before and was therefore able to complete extensive pre-, in- and post-flight visual acuity tests to confirm that the surgery did not compromise an astronaut's vision in weightlessness.

When I launched aboard Soyuz TMA 13 on October 12, 2008, I took with me a Slow

Scan TV device, so that I could transmit voice and live video as well. During my 12 day stay, I completed numerous school contacts, hours of open calls and planned to transmit SSTV pictures from a folder of prepared images or from the new SSTV camera I brought up. Upon arrival I set up a slide show as the test broadcast while I settled in aboard the ISS. These images included, test patterns, images of my father's flight, and some irreverent pirate flags labeled "Richard Garriott takes over the ISS", which apparently amused the ham community and others. Soon after I began my program of open calls and school programs, as well as live SSTV. I was amazed to discover how active the global ham community was and how technically savvy they were in decoding my data from space. I quickly learned that the ground stations receiving my transmissions could work out the battery life of the SSTV camera with more accuracy than I could onboard. I received very helpful data relayed through the community and via Russian mission control back up to me on the ISS. This feedback allowed me to work with much greater success, and with more dedication, knowing how closely I was being monitored globally!

During my 12 days on orbit, I made over 500 two way QSOs (contacts where we confirmed the two way exchange of call signs) and contacted over a dozen schools and Challenger Centers. I can absolutely state that my experience with ham radio from the ISS was the singular highlight activity of my time on orbit. The clear way that I touched the many I spoke with and the way they all touched me was far beyond what I could have speculated would occur when planning this activity. I am now very pleased and proud to have played my small part in the rich history of Amateur Radio.

References

- [1] Roy Neal, K6DUE, and General "Abe" Abrahamson in NASA were key players in obtaining approval to fly the transceiver on STS-9. Frank Bauer has coordinated a large ham effort to participate in the ISS activity. 🌐

PROCEEDINGS OF THE AMSAT-NA

2008 Space Symposium and AMSAT-NA Annual Meeting

The Harry Yoneda, JA1ANG, Space Symposium and Annual Meeting

Held October 24-26, 2008 in Atlanta, Georgia

Contents include articles on satellite construction and launch plus user ground station equipment: For example:

- Proposed Network-Centric Architecture for the Advanced Communications Package
by Timothy J. Salo, AD0DO
- Medium Earth Orbit - An affordable alternative to HEO?
by David Bowman, G0MRF
- AO-51 Operation Before, During and After the No Eclipse Period
by Gould Smith, WA4SXM
- Suitsat-2/Radioskaf-2: The Second Amateur Radio Space Suit Project
and Stepping Stone to Future Small Amateur Satellites
by Lou McFadin, W5DID
- Work Satellites with your HT!
by Clint Bradford, KC6LCS

And much more!

To order Proceedings 2008
(8½" x 11", 223 pages)

Minimum Donation

Now Available!

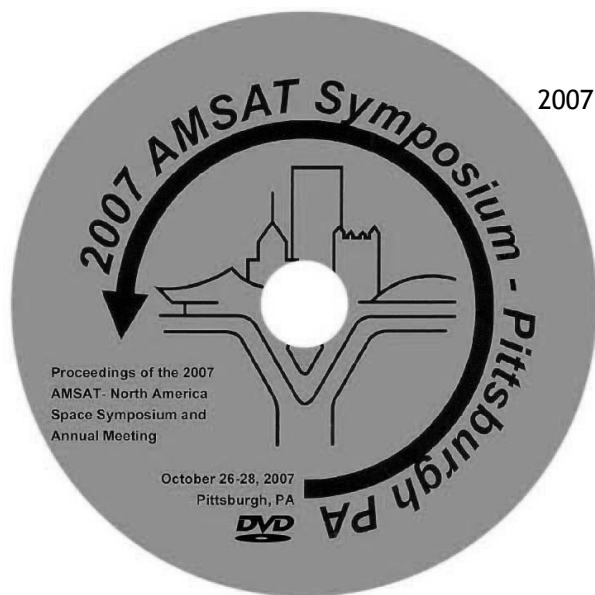
Write, telephone or FAX:

AMSAT-NA

850 Sligo Ave. #600
Silver Spring, MD 20910, USA

Tel: 301-589-6062
Fax: 301-608-3410

\$30 in the U.S. + postage.
For rate to your mailing address see: www.amsat.org and click on "AMSAT Store". VISA, MasterCard or Discover charges accepted.



2007 Proceedings DVD's also available. Contact the AMSAT Office.

THE R.F. CONNECTION

*"Specialist in
R.F. Connectors and Coax"*
<http://www.therfc.com>

301/840-5477
Fax 301/869-3680
E mail: rhc@therfc.com

Order Line 800/783-2666
Suite 11, 213 N. Frederick Ave.
Gaithersburg, MD 20877





AMSAT

NEWSLETTER

Issued by the Radio Amateur Satellite Corporation, P.O. Box 27,
Washington, D. C. 20044

Volume I, Number 1

June 1969

AMSAT OFFICERS	CONTENTS	Page
• President: Perry I. Klein Comsat Corp.	1. Editorial ----- S. H. Durrani	2
• Executive V.P.: Jan A. King NASA-GSFC	2. President's Desk ----- Perry Klein	3
• V.P. Engineering: George Kinal Communications & Systems, Inc.	3. Secretary's Column ---- Jim Puglise	4
• V.P. Operations: C. A. Petry ARINC	4. AMSAT - A New Amateur Satellite Program ----- C. A. Petry	5
• Secretary: Charles Dorian DOT	5. Progress Report on Australis- OSCAR A ----- Jan King	14
• Treasurer: R.W. Mostow "Forecast FM" Magazine	6. Orientation Kit I. Purposes of AMSAT and General Information II. Organization and Board of Directors III. Summary of Bylaws IV. Meeting Summaries and Milestones V. AMSAT Officers, Liaisons and Consultants	8 10 13
• Public Relations: W. A. Tynan Applied Physics Laboratory	7. AMSAT Member Clubs: Task Assign- ments	15
• Editor, Newsletter: S. H. Durrani Comsat Labs.	8. Announcements	16

AMSAT is 40!

Above is the cover page of the first issue of *The AMSAT Newsletter*, a predecessor to *The AMSAT Journal*. We've come a long way baby! Congratulations to the founders of AMSAT and thank you to the large number of hard working volunteers that have contributed to so much to AMSAT to make it successful for the past 40 years. You can see the AMSAT Articles of Incorporation on the Web site at www.amsat.org.

Happy 40th Birthday AMSAT!!

Ed Long
WA4SWJ
Editor, *The AMSAT Journal*



to orient the satellite in the higher strength Earth's magnetic field existing at the lower altitude.

Much hard work by volunteers from a number of countries went into the design, construction and testing of Phase 3A. In addition to the human labor expended to construct this spacecraft, AMSAT raised approximately a quarter of a million dollars in support of the project. Of course the German group had expended considerable labor and financial resources to complete Phase 3A as well.

The Phase 3A spacecraft was built mostly at the Goddard Space Flight Center, with much of the work being accomplished by volunteers in the "Fish Bowl," a small plywood building with the large windows erected in 1978 near the Goddard Visitors Center. See Figure 3 below.

As AMSAT's first decade came to a close, the satellite, which promised worldwide long distance communication for amateurs in many countries around the globe, was ready to be shipped to Kourou in French Guiana for launch aboard a huge Ariane rocket.

* indicates silent key

References

1. AMSAT, The Radio Amateur Satellite Corporation, Perry I. Klein, K3JTE, and William A. Tynan, W3KMY, *QST*, June, 1969, Page 54. 🌐

Apogee View continued from page 3 ...

will be reached, I continue to be hopeful that we will be in position to announce a new home later this year. In the meantime, our equipment will remain in storage and volunteers will perform an inventory review to determine which equipment will be retained for the new Lab or sold off if not needed.

ITAR (International Traffic in Arms Regulations)

A significant milestone was achieved on Friday, 13 March 09 when AMSAT submitted its 'Voluntary Disclosure' report to the Directorate of Defense Trade Controls Enforcement Division of the US Department of State. As I explained in earlier columns, AMSAT is tackling the issue of AMSAT's past actions that has raised questions about ITAR compliance and prevented AMSAT from moving forward on international satellite projects as well as inhibited our ability to export our project work.

In 2009, we are exporting antennas to the European Space Agency in the Netherlands for eventual placement on the Columbus Module on the ISS. They require an export license from the Department of Commerce. The request for a license was processed on an expedited schedule based on a request we made to Commerce and support we had from NASA. Our license for the antennas was issued by Department's Bureau of Industry & Security on 18 March 2009.

We also expect to export SuitSat-2 to Russia for eventual delivery to the International Space Station and subsequent placement

in a Russian spacesuit and release into space. This will require a license from the Department of State. We're aiming for a September 2009 delivery of SuitSat-2.

Both export opportunities require that AMSAT certify to government authorities our compliance with ITAR and export rules, so the voluntary disclosure process is essential to meeting governmental requirements. Our attorney, Frank Schucat has explained to the AMSAT leadership that it will likely take the State Department three to four weeks from receipt of our materials to review our submission and make an initial determination whether AMSAT may have violated any regulations.

Once we hear from the State Department, we will be in position to discuss with the State Department future AMSAT activities and address resumption of AMSAT participation in AMSAT-DL's P3-E project.

This process was done with the full and complete cooperation of our satellite builders who were interviewed over the phone by our attorneys, Frank Schuchat and Tim Pitner. I appreciate the candor and openness of our volunteers in discussing their past actions with them which added to the overall thoroughness of our voluntary disclosure process. I am confident that AMSAT will benefit significantly from this process and enhance our ability to work on international projects in the future.

73,

Barry, WD4ASW

AMSAT President 🌐



Figure 3: The "Fish Bowl" on the grounds of Goddard Space Flight Center, Greenbelt, MD.

The
AMSAT®
Journal



AMSAT - The First Decade by Bill Tynan, W3XO, w3xo@amsat.org

In the Beginning

It all began in early January, 1969 when George Jacobs, W3ASK, then the writer of CQ's propagation column and professionally associated with the Voice of America, spoke at a meeting of the Communications Satellite Corp. (COMSAT) Radio Club. In his talk on the Status of Project OSCAR, George noted that the west coast group, that had pioneered Amateur Radio satellites, had not been able to orbit any new spacecraft for about five years. He observed that the Washington area included many industrial, university and government laboratories employing hams who should possess the technical capability to construct spacecraft. Therefore he urged that a Washington-based organization be established to carry on the fine work begun by Project OSCAR.

A young Ph.D. in the audience named Perry Klein, K3JTE (now W3PK), was so inspired by George's talk and its challenge that he resolved to take action. And take action, he did. Wasting no time, Perry called a meeting at his apartment in southwest Washington, DC. To that meeting he invited representatives from various Amateur Radio clubs associated with DC area organizations and government agencies. Included was the club at the Johns Hopkins Applied Physics Laboratory where I was employed. Answering Perry's call, another JHU/APL Amateur Radio Club member, Jim Puglise, W3CBJ (now K9CQ), and I journeyed one cold winter evening from our homes in the Maryland suburbs down to southwest Washington – having no idea what we were getting ourselves into.

Attending, in addition to Perry, Jim Puglise and me, were George Kinal, K2MBU (now W3HPE), who worked for Communications and Systems Inc. and Cap Petry, W3AWN,* from Aeronautical Radio Incorporated (ARINC). Perry's enthusiastic recounting of George Jacobs' challenge inspired us to the point that we immediately agreed to form the organization which is now known as the Radio Amateur Satellite Corporation, or AMSAT.

Getting Organized

Regular meetings were held to draft a set of bylaws and an application for a charter from the D.C. Government.

More people soon came aboard; among them, Jan King, K8VTR (now W3GEY and

VK4GEY), of the Goddard Space Flight Center, Dick Daniels, WA4DGU (now W4PUJ), of NASA Headquarters, Ray Soifer, K2QBW (now W2RS), then serving with the U.S. Maritime Administration, Bob Carpenter, W3OTC, of the National Bureau of Standards, and Dick Mostow, W3YAV, publisher of Forecast FM magazine. With their help, work began to set up a formal organization and, by March 3, the Radio Amateur Satellite Corporation was officially incorporated in the District of Columbia as a non-profit educational scientific organization.

Thus from George Jacobs' original talk before the COMSAT Amateur Radio Club to incorporation, less than two months elapsed. Obviously we were enthusiastic to get started.

AMSAT's original concept was that it would be made up of Member Societies or clubs and members of these groups would participate through these Member Societies. That changed almost immediately as many individuals, not associated with any particular club, clamored to join.

AMSAT's interim Board of Directors was composed of the five who signed the articles of incorporation: Jim Puglise, George Kinal, Cap Petry, Jan King and Perry Klein. In June, two more were added to this interim Board: Capt Charles (Chuck) Dorian, W3JPT, of the U.S. Coast Guard and this author. These same people were elected by the members attending the first AMSAT Annual Meeting held at the Goddard Space Flight Center the following November. This board reaffirmed Perry as President, Jan as Executive Vice President, George Kinal Vice President for Engineering, Cap Petry as Vice President for Operations and selected Harry Helfrich as Treasurer. The original bylaws called for board nominations by one or more AMSAT Member Societies. This provision was later changed to also allow nominations by any five individual members as well as by Member Societies.

Telling our Story

How to inform the amateur community of the new organization and its intention to serve the hobby? QST was obviously the best vehicle to make such an announcement. So Perry and I set out to write an article for that publication. When we had completed our first draft, I showed it to my friend Vic

Clark, W4KFC,* ARRL Roanoke Division Director and a fellow Potomac Valley Radio Club member. (Vic later became ARRL President.) He suggested that what we had written needed a little more "pizzazz," as he put it - and offered a few suggestions. Taking his good advice, I added a few paragraphs and the article announcing the birth of AMSAT was submitted. [1]

In addition to announcing the formation of AMSAT to the amateur community as a whole, the organization needed a publication of its own to keep its membership informed and tell its story to others who might be in a position to help the cause. So, the *AMSAT Newsletter* was born. Its first editor was a non-ham Ph.D. who Perry knew at COMSAT, by the name of Sajjad Durrani. Sajjad did a fine job of documenting those early days. (It is from some of the forty-year-old copies of the *AMSAT Newsletter* that I obtained much of the information for this article.)

Various suggestions were received for a logo that would convey AMSAT's mission in an eye-catching manner, but none of the submission received seemed to be quite what we were looking for. So Dick Mostow went to a graphic artist friend at Washington's Channel 9 TV station who came up the familiar globe and arrow design which marks our organization today.

Also through Dick's efforts, AMSAT was able to obtain the address it has used for years: Post Office Box 27 Washington, DC 20044. Such low-number boxes were difficult to come by in the Nation's Capital.

Let's get Technical

For AMSAT's first technical endeavor, we fell into the trap so typical of Washington - generating paper rather than actually accomplishing something. What did we do? Why of course, we set up study groups to research various aspects of spacecraft design and submit reports on our findings. I drew two assignments. One involved gravity gradient stabilization and the other, nuclear isotope power systems. My task was to determine if either or both of these technologies would be suitable for use on Amateur Radio spacecraft. I received these particular assignments, not because I knew anything about the subjects, but because my employer, JHU/APL, had been active in both fields. Though my professional





Figure 1: The first AMSAT board members pose with Australis OSCAR-A. Left to right are: Jim Puglise, George Kinal, Cap Petry, Chuck Dorian, Bill Tynan, Jan King and Perry Klein.

work involved missiles, not satellites, I knew a number of people in the Lab's Space Department, so it was assumed I would be able to pick their brains for information.

An interesting aspect of these assignments is that none involved anything having to do with computers. Apparently none of us then dreamed of using computers in satellites. Possibly, if Tom Clark, WA3LND (later W3IWI) now K3IO, had been involved at the time, the major role computers would play in all types of spacecraft would have been recognized.

At a meeting called for presentation of the reports, I submitted mine and the others came with theirs. George Jacobs, who had been the inspiration for AMSAT, put us on the right course admonishing us for our typical Washington bureaucratic approach. He told us of the existence of an Australian amateur satellite sitting in a garage in California that had been sent by its builders at the University of Melbourne to Project OSCAR in hopes of a launch. Why should not our first project be to prepare this spacecraft for launch? Everyone agreed George was right. Amateur Radio needed a new satellite soon, not a stack of visionary reports on what might be - years in the future.

So, thanks again to George Jacobs, AMSAT was off and running - this time, in the right direction.

Agreement was reached with Project OSCAR and the students and faculty members at the University of Melbourne for AMSAT to obtain the satellite and prepare it for launch. Jan King was given the responsibility for the technical work necessary to prepare the Australian spacecraft for launch.

In view of the key role Project OSCAR had played in getting Amateur Radio started

in space, it had earlier been agreed that all AMSAT satellites would bear the name OSCAR. This policy would begin with the Australian spacecraft. Thus it would be known as Australis OSCAR-A prior to launch and Australis OSCAR -5, or AO-5, once in orbit.

Australis OSCAR-5

Thanks to the dedicated work of Jan and his team, Australis OSCAR-A was ready for launch by the end of 1969. Jan and a co-worker at Goddard, Harry Helfrich, W3DWF (later W3ZM),* were able to arrange a ride for it as a secondary payload on a Delta vehicle scheduled to put a weather satellite into orbit.

AO-5 roared into orbit in January, 1970, carrying beacons on 2 meters and 10 meters. In addition to getting Amateur Radio back into space, this satellite had two principal objectives. The 10 meter beacon was to prove the utility of that band for space use, and the command function would furnish the first demonstration of ground command of an Amateur Radio satellite. Bill Dunkerley, WA2INB, arranged for the Talcott Mountain Science Center in Connecticut to set up the necessary equipment to successfully command AO-5.

The ability to command amateur satellites would become increasingly important in later years as AMSAT, and similar organizations in other countries, endeavored to convince their governments and other launch authorities that amateurs could control their spacecraft. Permission for launches would often hinge on being able to furnish such assurance.

AMSAT Helps Launch Careers as well as Satellites

A young Englishman attended some AMSAT

meetings, apparently to learn what this amateur satellite business was all about. Eventually he established a spacecraft construction facility at the University of Surrey, near London. It was this university group that later launched UoSat OSCAR-9 (UO-9), UO-11 and a number of other amateur and research satellites. Later, he formed Surrey Satellite Technology to commercialize the work done at the university. For his satellite work, and the importance it has represented to Great Britain; this now, not-so-young-anymore Englishman Dr. Martin Sweeting, G3YJO, was knighted. I like to think that AMSAT played a role in Sir Martin's success.

I believe that Jan King will agree that his association with AMSAT helped him vocationally in later years in gaining several space-related positions with various organizations. There are others who will be mentioned in future articles chronicling our organization's later decades.

AO-6, AMSAT's First Wideband, Multiple-user Transponder Satellite

Once the AO-5 mission was complete, design and construction began on our first from-the-ground-up project. In orbit, it would be AMSAT OSCAR-6, or AO-6. This satellite contained a 2 meter up/10 meter down transponder, a 21-channel command decoder, a 435.1 MHz beacon and a Morse code telemetry system.

Since no information existed on how a multiple-user transponder would behave when exposed to many signals in its passband simultaneously, a prototype of the 2 to 10 meter transponder was built and flown in a light plane. With Jan occupying the rear seat monitoring the transponder on a small HF receiver and a pilot and copilot at the controls, the plane took off one Saturday morning from Friendship Airport, now called Baltimore Washington International Airport (BWI).

The route took them up the East Coast to near Boston, then west over New York state and across the Niagara Peninsula of Canada. They landed late that afternoon at Pontiac, Michigan - a logical place to stop as Jan's parents lived in the area, thus providing the plane crew a free place to stay overnight. The following day they resumed the flight, proceeding to near Chicago and making it a point to fly over Kokomo, Indiana, where AMSAT already had several loyal members who were eager to participate in the experiment. The flight ended Sunday



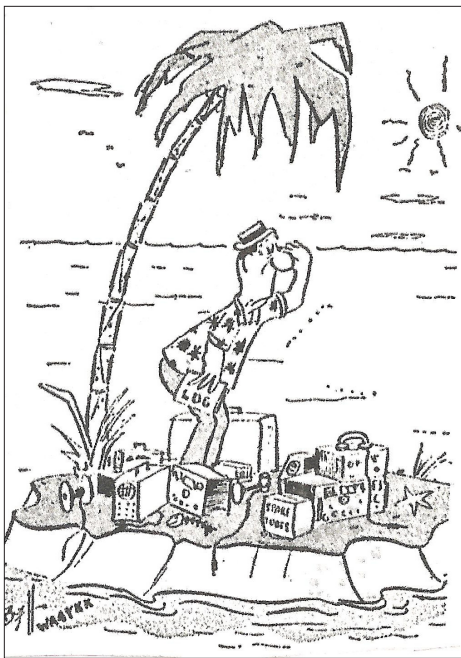


Figure 2: Satellites go along on DXpeditions.
Reproduced through the courtesy of QST.

afternoon where it had begun.

A group of ground-based volunteers tracked the plane, communicating with Jan via 2 meter FM and relaying the aircraft's position and other information to me on 40 meters. I then reported the information to the other AMSAT folks in the DC area via one of the local 2 meter FM repeaters. It was a thrill when I suddenly heard Jan's voice as the plane crossed the Allegheny mountains.

Two unfortunate events occurred during OSCAR-6's construction and testing. In conducting a thermal test on the flight transponder in his wife's oven, Dick Daniels inadvertently left the oven on too long and burned the thing to a crisp - necessitating construction of another unit. Worse was the sudden death of Harry Helfrich, who had been such an inspiration and great help to AMSAT in arranging for environmental testing and obtaining a launch for AO-5. Harry died suddenly while jogging one very cold January morning.

Harry's death left both a technical and administrative voids in AMSAT's activities. Since he had been serving as Treasurer, that position had to be filled immediately. Bill Hook, W3QBC, of the National Institutes of Health Radio Amateur Club, an early member, stepped up and took over this vital post.

Despite the magnitude of the job and these setbacks, AMSAT OSCAR-6 was launched on October 15th, 1972. But a problem with the new satellite became

apparent almost immediately. Although it was heard by European stations soon after launch, when it first came over Australia, the down-under command station reported no signals. Jan quickly flashed word to send an ON command, whereupon the spacecraft immediately again came to life. It didn't take long to conclude that AO-6 had a mind of its own. Even though it contained no on-board computer, only logic control circuitry, its transponder would turn on and off for no apparent reason. To overcome this pesky situation, Jan initiated what he termed, "intensive use of ground command." To maintain the bird in the desired mode, commands had to be sent by the various command stations around the world at every opportunity. Several dedicated volunteers, around the world, including Randy Smith, VE2BYG (later VE3SAT), and Larry Kayser, VE3QB,* automated their stations to accomplish this arduous task even when they could not be present.

The first DXpeditions involving amateur satellite operation took place during AO-6's lifetime. One such DXpedition was to Penrhyn Island (also known as Tongariva) in the North Cook chain. Though HF operation was the group's main objective, some among them wanted to try the new satellite as well. Thanks to Chip Angle, N6CA, they had the appropriate equipment. But, the on-again/off-again nature that AO-6 continued to display represented a real challenge to their success in making satellite contacts.

By the time of the AO-6 launch, I had been designated as Vice President for Operations and therefore had the responsibility to coordinate the various command stations around the world. In that position, I endeavored to support the Penrhyn Island DXpedition by having the satellite on when it was in the vicinity of the Cook Islands. To accomplish this, I depended principally on our New Zealand command station operated by Bruce Rowlings, ZL1WB. Bruce came through and the Penrhyn group was able to work a couple of US West Coast stations via AO-6, thus demonstrating that satellite operation could be a useful addition on future DXpeditions. (The cartoon which appeared in the QST article that Perry and I wrote announcing the formation of AMSAT, shown in Figure 2, seems especially apropos of this.)

During AO-6's lifetime, a request came from the Boeing Amateur Radio Club. They asked us to make AO-6 available so

that they could attempt to command a radio controlled model airplane through it - an interesting experiment indeed, with all sorts of implications applicable to the present-day world.

Two Twin City hams, John Fox, W0LER, and Ron Dunbar, W0MJS, reported an odd effect on reception of AO-6's 435.1 MHz beacon. As the satellite traveled away from them toward the south, they noted that, at one point in the pass, that the Doppler shift became inverted. (The frequency rose rather than falling, as one would expect for a departing object.) They did not observe this effect on AO-6's lower frequency beacons, or on other satellites, but *did* note it on some U.S. Navy navigational spacecraft with beacons in the vicinity of 400 MHz. John's and Ron's observations elicited much speculation in scientific circles as to the cause of the strange phenomenon.

AO-6 supported the first satellite WAS. Jack Colson, W3TMZ, had worked diligently to put all fifty states into his log and finally lacked only Hawaii. KH6 is about a 4,400 mile hop from Maryland - close to the limit of the range afforded by AO-6's 900 mile high orbit. That, plus the fact that the satellite was often not on when it was supposed to be, made completing of that last contact seem doubtful. Many times, when the bird was in the right spot, the transponder was silent. But one evening the satellite gods were with Jack. The satellite was in the right position. The transponder was on. W3TMZ, and Butch Miller, KH6HLK (now NN2T), the Hawaii station he had been scheduling, were both on deck. The first satellite WAS went into the record books. Some dozen more joined Jack before AO-6 ceased to function in June 1977.

AO-7 and DJ4ZC

Following AMSAT OSCAR-6, came AO-7. This spacecraft, built in an improvised clean room in Jan's basement, carried two transponders. One was a 2 meter to 10 meter unit like the one on AO-6. This combination of bands had been dubbed, Mode A. The other transponder was supplied by a German group led by Karl Meinzer, DJ4ZC, of the University of Marburg. Karl had earlier provided an in-band 2 meter transponder to Project OSCAR, which had never flown. The 70 centimeter to 2 meter transponder on AO-7 proved very successful. The design employed HELAPS (High Efficiency Linear Amplification through Parametric Synthesis) which had been the subject of Karl's doctoral

thesis. Although signals from AO-7's Mode A transponder were not as robust as those from the one on AO-6, its Mode B transponder produced very strong downlink signals, making AO-7 very popular with hams throughout the world.

Inter-satellite Relaying Demonstrated

The overlapping lifetimes of AO-6 and AO-7 provided amateurs an opportunity to accomplish something never before achieved with any other satellite, government or commercial – relaying signals from one satellite to another. This satellite-to-satellite mode of communication has since found application in non-amateur spacecraft, including NASA's Tracking and Data Relay Satellites (TDRS).

Satellite-to-satellite link-up became possible when AO-6 and AO-7 were within line-of-sight of each other so that the 2 meter signals from AO-7's Mode B transponder could be received by AO-6's Mode A transponder and thus sent back to Earth on 10 meters. A number of satellite operators took advantage of these opportunities to complete QSOs via this cross-satellite route. The first to do so were Ray Soifer, K2QBW (now W2RS), and Ben Stevenson, W2BXA. Incidentally, Ben later became the first to earn a satellite DXCC. While Ben, W2BXA, was the first to actually receive the Satellite DXCC award, Pat Gowen, G3IOR, was the first to work the required 100 countries. But Pat was, and still is, notoriously slow to collect QSLs, so he eventually received Satellite DXCC Number 4. Incidentally, G3IOR was elected to the AMSAT Board in October, 1976, the first non-US citizen to serve. Over the years, other non-US board members have been Haruo Yoneda, JA1ANG,* Junior deCastro, PY2BJO, and John Henry, VE2VQ.

Satellites Come to the Rescue

An experiment conducted using both AO-6 and AO-7 involved sending a signal through each satellite, then computing the location of the station sending that signal by the Doppler shift. Confirmation of the utility of this technique to locate ground-based transmitters eventually led to initiation of the international SARSAT (Search And Rescue SATellite) Project to locate downed aircraft and lost mariners.

Back from the Dead

Incidentally, though AO-7 was launched in November, 1974, and went silent in the summer of 1981, its signals were suddenly

and unexpectedly received again one evening in June, 2002, by G3IOR. The reappearance of long-departed AO-7 produced much excitement and many theories as to why and how it had happened. It has been surmised that, though the satellite's batteries had long since ceased to furnish power, its solar cells still provide power when in sunlight. Apparently AO-7's original demise was caused by a short circuit in one or more battery cells and that opening of the short made the solar panel power available to run the transponders - bringing the old bird back to life after so many years. But, since AO-7 can no longer be easily commanded, one can never be sure which transponder will be active. Many satellite enthusiasts make a special game of using this derelict spacecraft.

AMSAT Membership Swells

By the end of 1973 our membership had reached the one-thousand mark. Two who joined by that time, and made notable contributions to the organization were Tom Clark, WA3LND (later, W3IWI now K3IO) and Joe Kasser, G3ZCZ. Tom became very active in AMSAT activities and was elected to the board in 1974 and named executive VP in 1976.

Joe Kasser, G3ZCZ, who had who had emigrated to the U.S. from England several years before joining AMSAT, took over the editorship of the *AMSAT Newsletter* in late 1974. Joe was also responsible for making a number of technical contributions, especially in the then new field of microprocessor-based computers.

ARRL Does Its Part

To replace the by-then dead AO-6 and provide a Mode A capability superior to that offered by AO-7, the League funded AMSAT to build AO-8. In addition to a Mode A transponder, AO-8 carried a 2 meter up/70 centimeter down transponder built by the Japanese AMSAT group called JAMSAT. As a result of its Japanese origin, this combination of bands was dubbed Mode J. AO-8 was launched in March, 1978 and performed well under stewardship of ARRL volunteer controllers for five years.

The Soviets Contribute to Amateur Space

In October, 1978, AMSAT's and ARRL's efforts to provide satellites for the world's licensed amateurs, was augmented by hams from the Soviet Union. Radio Sputnik 1 (RS-1) and Radio Sputnik 2 (RS-2) were sent into orbit simultaneously on a single launch

vehicle. Both of these satellites carried Mode A transponders and remained popular for a number of years.

Martha Arrives

By 1978, AMSAT membership had grown such that Perry Klein was no longer able to keep up with the administrative paperwork by himself. From a couple who lived in the same building, he learned that their daughter, though employed as a teacher in the Headstart program, was willing to work part time. That's how Martha Saragovitz came to AMSAT. Martha remains our only full time paid employee. Incidentally, she met her husband, John Shew, N4QQ, as a result of her association with AMSAT. So AMSAT can be credited with fostering a romance. Of course, over its 40 years, AMSAT has come close to fostering a few divorces as well!

At first Martha worked in Perry's bedroom, which raised a few eyebrows. When Perry bought the adjoining apartment, AMSAT's office function was moved into that space. However, Perry's in-laws frequently visited and stayed in the second apartment. More than once Martha arrived at work to encounter strange people still in their pajamas.

The Phase 3 Era

During the mid-1970s, work began on a cooperative project with Karl Meinzer and his German associates on a new high altitude amateur satellite. All of our previous spacecraft had been in relatively low orbits, thus affording only limited DX potential. This new type of spacecraft was referred to as Phase 3. The first OSCARs, including OSCAR-5, carrying only beacons, were referred to as Phase 1, and the low-orbit-transponder-equipped satellites, such as OSCARs 6, 7, 8 as well as the RS birds, were termed Phase 2. Phase 3A, the first of the Phase 3 satellites, was to provide worldwide coverage from a Molniya orbit. This kind of orbit, first developed by the Soviets to provide coverage across their very wide northerly country, involves a high latitude (approximately 64 degrees) inclination to the Equator, with apogee occurring at the northern-most point in the order of 36,000 kilometers (23,000 miles) and a relatively low perigee, which of course falls in the southern hemisphere. The low perigee enables the use of on-board electromagnets

continued on page 27 ...



Reach for the stars.

N3UC, formerly N4USI, control operator of AO-27, says, "AO-27 may be getting old and failing at times, after 15 years circling the earth. But, my IC-910H that I use to control AO-27, using data transmissions, has never failed me".

Icom 910H The perfect satellite rig.



Have fun communicating with these satellites using the IC-910H:

AO-27, SO-50, AO-51, and VO-52.

In the near future, check out these satellites:

AMSAT-Phase 3E, AMSAT-Eagle, SumbandilaSAT, and KiwiSAT.

Coming to the sky near you! Visit an authorized Icom dealer today!

amateur | avionic | land mobile | marine | receiver | system | www.icomamerica.com

*For further satellite information visit www.amsat.org.

©2009 Icom America Inc. The Icom logo is a registered trademark of Icom Inc. AMSAT is a registered trademark of the Radio Amateur Satellite Corporation. 30122

ICOM®